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THE "PLAGIAULACOID" TYPE OF MAMMALIAN DENTITION

A STUDY OF CONVERGENCE

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Abel (1931, pp. 326, 328) has appropriately designated as "Plagiaulax-typus" or "plagiaulacoider Typus" a pattern of mammalian dentition which has very definite and peculiar characters and has arisen quite independently at least four times. This independent rise of the same complex type of structure in animals of widely different relationships gives an unusually interesting opportunity for the study of convergence, an opportunity not fully or, in some cases, not accurately seized in the previous work by Abel (especially 1911, pp. 541–547), by Lohr (1913), or by me (especially 1928A, pp. 8–9). It is therefore proposed to describe this dental type and to point out the resemblances and differences in its several occurrences, their probable origins, and their meaning.

The plagiaulacoid type of mammalian dentition is so called because it is typically displayed by the Plagiaulacoidea. The name is also appropriate in origin and meaning, being derived from πλάγιος, oblique, + αὖλαξ, groove. This type of dentition may be defined as that in which one or more of the lower cheek teeth are modified into large, simple, laterally compressed blades with serrated cutting edges. There are, as detailed below, other important features, chiefly the presence of enlarged procumbent incisors, which always accompany this sort of shearing tooth, but are not exclusively associated with it.[1]

The groups in which such serrated lower shearing teeth are known, and the teeth so modified in each, are as follows:

[1] This definition is more limited than that of Abel, which includes *Plesiadapis*, adaptively somewhat similar but without serrated shearing blades.

MULTITUBERCULATA
- Plagiaulacoidea
  - Plagiaulacidæ ..... P_{2-4}, P_{2-4}
  - Ptilodontidæ ..... P_4

MARSUPIALIA
- Cænolestoidea
  - Cænolestidæ (*Abderites*, etc.) ..... M_1
  - Polydolopidæ ..... M_1
- Phalangeroidea
  - Phalangeridæ (*Burramys*) ..... P_3
  - Macropodidæ (*Bettongia*, etc.) ..... P_3

PRIMATES
- ?Tarsioidea
  - ?Anaptomorphidæ (*Carpolestes*, etc.) ..... P_4

Seven different families thus have in all or in some of their genera a plagiaulacoid type of dentition, but this may not represent more than four independent origins. It certainly did not originate independently in both plagiaulacids and ptilodontids, the latter inheriting it from the former, and it possibly arose but once in the Cænolestoidea and once in the Phalangeroidea, or if it did arise more than once in either or each of these groups, its origin was among very closely related lines.

A brief description of these dentitions will serve as preface to discussion of them.

Plagiaulacoidea.—(See Simpson 1926, 1928B, 1929B; Granger and Simpson 1929.) The dental formula varies from $\frac{3.0.5.2}{1.0.4.2}$ (*Ctenacodon, Bolodon*) to $\frac{2.0.1.2}{1.0.1.2}$ (*Tæniolabis*), but the latter is so modified as to have lost the typical plagiaulacoid character, which is, however, preserved in forms with a probable minimum formula of $\frac{2.0.3.2}{1.0.1.2}$. The lower incisor is much enlarged and may be pointed, as in most forms, or may become rodent-like, very hypsodont, with enamel band, as in *Eucosmodon*. The enlarged upper incisor is I^2, as a small I^1 is present in the Jurassic but lost in later forms. I^3 seems always to have been retained, but is smaller than I^2 and may be vestigial. In most cases I^2 has a lower or shorter crown than the lower incisor, has an accessory cuspule, and is pointed forward so that in occlusion the incisors meet at about 90°, although presumably the upper incisors were more rodent-like in *Eucosmodon*.

In the Plagiaulacidæ P_{2-4} (*Ctenacodon*), or P_{2-4} (*Plagiaulax*), together form a compressed, serrated shearing edge and the preceding tooth, P_1 or P_2, has little function except as a buttress. In the Ptilodontidæ only P_4 is a shearing tooth, but it is usually relatively enlarged, and P_3 is a little styliform support wedged into a notch in the anterior end of P_4 or is absent.

In all these forms (except the Tæniolabididæ, not here under consideration) there are two or three anterior upper premolars, which do not occlude with any

lower teeth. They are rounded or quadrate, with three or more sharp but low conical cusps. The upper shearing teeth are two (Plagiaulacidæ) or one (Ptilodontidæ) in number and are very unlike the lowers, consisting of a row of semiconical cusps, with a shearing edge on their inner side and usually one or two more or less complete additional rows external to this. Contrary to what is sometimes stated (e.g., Lohr 1913, p. 716), the lower shearing tooth does not work in a groove of the opposing tooth, but shears up its inner face, as in *Bettongia*, etc., although the morphology is rather different. The molars, two in each jaw, are grinding teeth with crescentic or subcrescentic cusps, highly variable in number, arranged in longitudinal rows and grinding in valleys of the opposing teeth.

Cænolestoidea.—In the Abderitinæ and Polydolopidæ there is a single pair of enlarged but rooted and not fully gliriform incisors. The upper anterior teeth are poorly known. In the lower dentition there intervenes between the large incisor and the shearing tooth a series of vestigial button-like teeth. In the Abderitinæ the last premolar is remarkably like the penultimate in ptilodontids, a small styliform tooth inserted in a notch in the front end of the large shearing tooth, here M_1. In the Polydolopidæ the shearing tooth is simple, with denticulate rim but with lateral ridges not exactly corresponding to the denticles as they do in multituberculates. In the Abderitinæ it has lateral ridges from each denticle and also retains a small basined heel. M_2 has the anterior end raised into a point, partaking in the shearing edge in the Polydolopidæ but not in the Abderitinæ. In both, the posterior lower molars are brachyodont, with shallow basins, imperfectly differentiated trigonid and talonid, and a variable number of rather poorly distinguished cusps along the rims. Contrary to the condition in multituberculates, the upper shearing teeth of the polydolopids do resemble the lower, but they are two in number, P^2 and M^1. M^{2-4} are broad, with shallow central basins and numerous low cusps. The molars are not especially adapted for anteroposterior grinding as in the multituberculates. Lohr (1913, p. 716 and fig. 7) has also misinterpreted the occlusion and mechanics of these teeth. He supposes the lower shearing tooth to occlude orthally posterior to the upper and the cutting to be between the vertical anterior edge of the lower and posterior of the upper, by horizontal anterior motion of the lower jaw. This is not at all true. The shearing edges directly oppose each other and the motion of the jaw in shearing is orthal, not propalinal. The shearing edges are not vertical.

Phalangeroidea.—(See Broom 1895, Bensley 1903, Abel 1911, etc.) Here again there are enlarged incisors, one in each jaw, more pointed than fully gliriform and rooted, although, especially in the lower jaw, very high crowned. Teeth between this and the shearing teeth are reduced in number and small (upper jaws of ratkangaroos etc., lower jaw of *Burramys*) or absent (lower jaw of *Burramys*, etc.). The shearing teeth are similar in the two jaws in *Bettongia* and its allies. In *Burramys* the upper teeth are unknown. In both there are lateral ridges corresponding to the denticulations of the edge. The molars are low crowned with a general bilophodont pattern, but not very sharply crested.

?*Anaptomorphidæ.*—(See Matthew and Granger 1921, Simpson 1928A, 1929A, Jepsen 1930.) Among primates, only *Carpolestes* and *Carpodaptes* have the plagiaulacoid type of dentition well developed, although several other genera trend toward it. *Carpolestes* is best known. The incisors are not known, except that there was an enlarged procumbent lower incisor. Between this and the shearing

tooth were several one-rooted, button-like vestigial teeth like those of Polydolopids or Abderitines. The lower shearing tooth, P_4, is a simple compressed blade rising to a central apex, with denticulate edge and poorly developed lateral ridges. The anterior end of M_1 also participates in the shearing action, but has only two

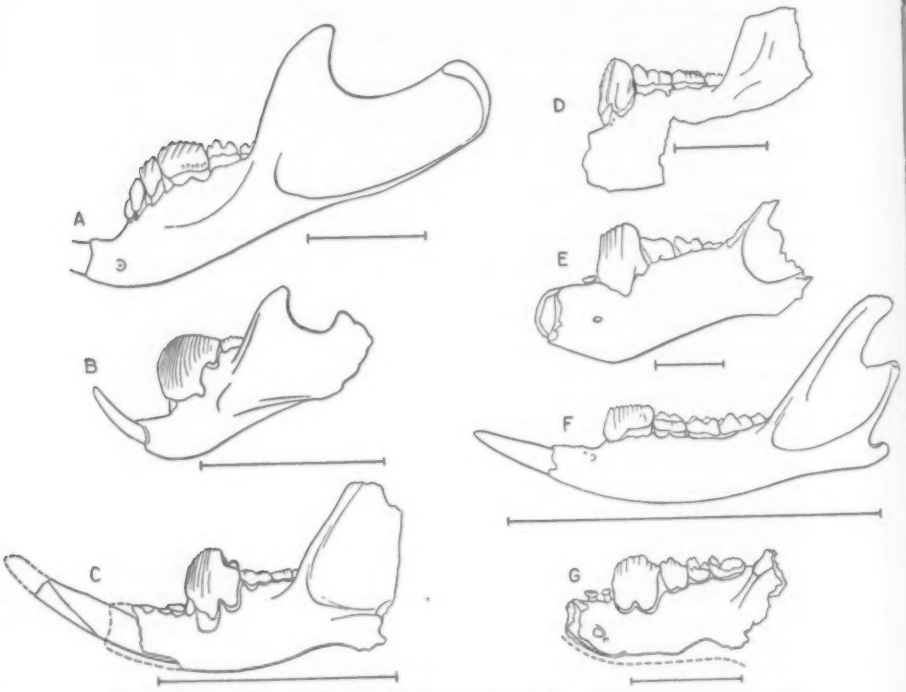

FIG. 1. LEFT LOWER JAWS OF MAMMALS WITH DENTITIONS OF PLAGIAULACOID TYPE, EXTERNAL VIEWS

A, *Ctenacodon*. B, *Ptilodus*. C, *Abderites*. D, *Polydolops*. E, *Burramys*. F, *Bettongia*. G, *Carpolestes*. The horizontal line in each case shows the natural over-all length of the specimen as drawn. E redrawn after Broom and G redrawn after Jepsen.

cuspules and is followed by a nearly normal basined talonid. There are two upper shearing teeth, P^{3-4}, of nearly similar character and remarkably like those of some multituberculates in form, but with different mechanical relationships. They have three longitudinal rows of cusps, the inner row shorter. The large lower shearing tooth occludes with the posterior part of P^3 and anterior of P^4

and shears against the inner sides of their median cusp rows. The molars are brachyodont and nearly bunodont, of simple anaptomorphid pattern.

EXTENT OF CONVERGENCE

It is clear that resemblance in these groups is not confined to the denticulate shearing teeth, but extends to greater or less extent throughout the dentition. It is a complex and thorough-going example of convergence. The principal characters involved are:

1. One pair of incisors enlarged above and below.
2. With very rare exceptions, these are rooted and do not have the markedly limited enamel band and chisel-edge of rodent incisors.
3. The upper incisors are relatively smaller and have lower crowns.
4. Upper and lower incisors generally meet at nearly 90°.
5. Teeth between these incisors and the shearing teeth are reduced or lost and diastemata developed.
6. Shearing teeth, more variable in the upper jaws, but in the lower jaws always laterally compressed blades with cuspidate edges, developed immediately anterior to the effective molar surface.
7. The effective molars, posterior to the shearing teeth, are brachyodont. They vary greatly in pattern but are in all cases crushing or grinding teeth, broadly overlapping and opposing each other without any cutting or piercing action.

It may also be noted that all these animals are small, and many are minute. In addition to these resemblances common to all, there are others acquired independently by some, but not all, apparently less important to this particular mode of life and for that reason all the more striking:

1. In *Carpolestes*, abderitines, and polydolopids most or all of the teeth between the lower incisors and shearing teeth are reduced to one-rooted vestiges with depressed button-like crowns.
2. In abderitines and most ptilodontids the tooth preceding the shearing tooth is small and styliform, fitting into a notch at the anterior end of the shearing tooth.
3. In *Carpolestes*, plagiaulacids, and ptilodontids there are numerous, sharp but low, more or less conical cusps in the upper premolar series which have no direct occlusal relations with any lower teeth or cusps.
4. In *Carpolestes* and polydolopids, the anterior end of the tooth following the lower shearing tooth is elevated and enters into the shear.

Yet these remarkable functional convergences are accompanied by differences which reveal that these animals come from four very different lines of ancestry. As so often occurs, the convergent habitus characters have been mistaken for heritage characters and supposed to indicate true affinities in some cases. When the Jurassic plagiaulacids were discovered, it was supposed that they must be ancestral to *Bettongia* and its allies, and until quite recently, Ameghino's view that the polydolopids were multituberculates has been widely accepted. In fact the basic non-adaptive differences between the teeth of these various groups of animals are great, and this makes the convergence all the more noteworthy in showing from what very different original conditions these very similar structures have been evolved.

In multituberculates, kangaroos, and *Carpolestes* and its allies, it is the last premolar or premolars above and below that form the shearing teeth, whereas in polydolopids it is M_1 below and P^3 and M^1 above. In multituberculates the shearing tooth is always followed by two cheek teeth, in *Carpolestes* and its allies and in the polydolopids by three, in the kangaroos by four.[2]

The pattern of the posterior cheek teeth is distinctive in each group, and although modified in all, clearly indicates the separate ancestry of each. The multituberculate molar is, as is now well known, very characteristic and unlike

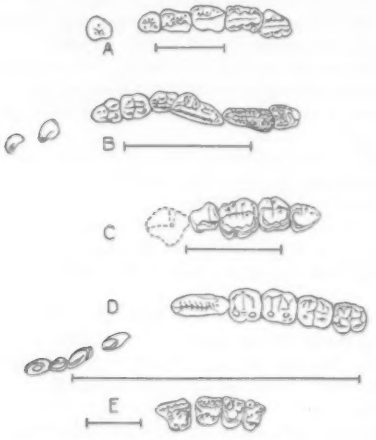

FIG. 2. LEFT UPPER TEETH OF MAMMALS WITH DENTITIONS OF PLAGIAULACOID TYPE, CROWN VIEWS

A, *Bolodon*. B, *Ptilodus*. C, *Polydolops*. D, *Bettongia*. E, *Carpolestes*. The horizontal line in each case shows the actual length of the tooth series shown. E redrawn after Jepsen.

anything occurring in any other order. In polydolopids the polybunodont pattern can be traced back to one very like that of cænolestids. *Bettongia* and its allies have typical macropodid molars, and *Carpolestes* and its closer relatives have molars in close accordance with those of anaptomorphids or tarsiids in which this sort of shearing premolar has not developed.

The general osteology is poorly known in most of the fossil forms, but it also clearly shows this great difference of ancestry but similarity of habit. For instance, in multituberculates there is no true angular process, but only a non-angu-

[2] This is not due to adaptive reduction but to the facts that the original number of molars in the several groups was different, two in multituberculates, three in placentals, and four in marsupials, and that the teeth are not homologous in every case. No molars have been lost in any of these groups.

late pterygoid crest. In *Bettongia*, polydolopids, and the other marsupials here discussed there is the typical inflected angle, and in *Carpolestes* a non-inflected angle of placental type.

The known time ranges of these groups are as follows:

Plagiaulacidæ: Upper Jurassic—Lower Cretaceous.
Ptilodontidæ: Upper Cretaceous—Lower Eocene.
Abderitinæ: Eocene—Miocene.
Polydolopidæ: Eocene.
Phalangeridæ, *Burramys:* Pleistocene.
Macropodidæ, *Bettongia*, etc.: Pleistocene—Recent.
?Anaptomorphidæ, *Carpolestes*, etc.: Paleocene.

STRUCTURAL ORIGIN AND EVOLUTION

The origin of the multituberculate shearing teeth is unknown, since they are already fully formed when first encountered. The chief advances pertinent to the present study are (Simpson 1928B, 1929B):

1. Reduction of premolars from $\frac{4}{4}$ to a minimum (in Ptilodontidæ) of $\frac{2}{2}$.
2. Relative enlargement and complication of last premolars.
3. Concentration of upper shear, at first equally on two teeth, later wholly on one tooth, although other upper premolars are not all lost.
4. Increase in size, cusp number, and, in upper teeth, cusp rows of the two molars.
5. In one side line, *Eucosmodon*, acquisition of truly gliriform incisors.

All this perfects but does not significantly change the adaptive type already present in the earliest known forms.

I have elsewhere (Simpson 1928C) rather fully expressed my views as to the origin and evolution of the trenchant premolars of abderitines and polydolopids. Discovery of new material and much subsequent study have not led to any significant modification of the theory there expounded. It is, in brief: That these shearing teeth arose from normal cænolestine tuberculosectorial molars as seen in *Halmarhiphus* or the recent cænolestids; that the second structural stage is seen in Palæothentinæ, in which the paraconid-protoconid blade of M_1 is elongate anteroposteriorly and trenchant, but only slightly elevated and not serrated; that the next structural modification is that of the Abderitinæ with this blade elevated and serrated, but still followed by a nearly normal talonid; that in the Polydolopidæ even this talonid is lost; and that the other changes, much simpler and presenting no real difficulties, proceeded *pari passu* with these modifications of the first molar.

In the Phalangeridæ and Macropodidæ, although the end result was rather similar, it seems to have been reached in a much simpler and more direct way. A reasonably probable structural sequence (although of course not representing the actual phylogeny) as far as regards the shearing tooth, can be arranged among recent or Pleistocene forms, for example the following:

Phalangista: P^3_2 of nearly normal premolariform type, only slightly enlarged.
Macropus: P^3_2 somewhat more trenchant.
Caloprymnus: P^3_2 larger, definitely trenchant, indistinctly serrated.
Bettongia: P^3_2 very large, trenchant, and serrated.

Many other genera might be cited in support of such a structural sequence. They indicate beyond much doubt that the shearing teeth in this group have not passed through a molariform condition, as they did in the ancestry of the Polydolopidæ, but were directly modified from simple compressed premolars. These similar teeth thus arose from very dissimilar ancestral types.[3]

In considering *Carpolestes*, it is a fortunate circumstance that we have in all probability its direct and certainly its structural immediate ancestor in *Elphidotarsius* (see Gidley 1923).[4]

In the latter, P_4 differs from the condition in more normal anaptomorphids only in having the anterior crest of the main summit somewhat prolonged and divided into three denticles. Still greater elongation, multiplication of the denticles, and loss of the heel as such readily give rise to the *Carpolestes* type. The exact mode of origin of the extraordinary P^{3-4} of *Carpolestes* is not known, but there is no great theoretical difficulty in deriving them from the transverse P^{3-4} of normal anaptomorphids with one main outer and one main inner cusp, by anteroposterior elongation of the crests of these teeth and growth of denticles on them.

There is thus good reason to believe that in kangaroos, etc., the shearing teeth were derived from premolars not at all molariform, in *Carpolestes* and its allies from premolars submolariform, and in polydolopids from thoroughly molariform teeth (except P^3).

Lohr (1913) indicates very different histories and relationships for all these groups except *Carpolestes* and its allies, not yet known when he wrote his paper. He divides them mechanically into three different types, but as shown above his conception of occlusion and mechanics in the extinct forms was erroneous and the three-fold division is not valid. He gives an elaborate tree which he recognizes as not having any phylogenetic reality, but which he claims to be a "Stufenreihe." Even on a structural basis, this tree is impossible. Merely to suggest how at variance it is with any possible reality (particularly in the proper application of Dollo's law), it may be noted that in one line he has non-shearing teeth (*Cænolestes*, *Garzonia*) giving rise to semi-shearing M_1 (*Metæpanorthus*), then to almost fully shearing M_1 (*Parabderites*), so far a valid structural sequence, but then returning again to a semi-shearing condition (*Callomenus*), then back to the next preceding almost fully shearing stage (*Abderites*), then to a completely shearing stage (*Archæodolops*), then reversing entirely to a non-shearing stage (*Phalanger*), and suddenly back to completely shearing again ("*Propolymasto-*

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[3] A further interesting feature in the rat-kangaroos is the progressive rotation of the shearing teeth (Bensley 1903), but this seems to have no definite bearing on the convergence of form.

[4] Abel (1931) in his extremely valuable review of fossil primates does not make it quite clear that *Elphidotarsius* (with its contemporaries *Palæchthon*, *Paromomys*, *Pronothodectes*) is definitely older than *Carpolestes* (with its approximate or exact contemporaries *Carpodaptes*, *Plesiadapis*, *Labidolemur*, etc.). The former is Middle Palæocene (Torrejon) in age, the latter Upper Palæocene (Tiffany). He also gives *Plesiolestes* as of Lower Palæocene age on pages xiv and 269, but as Torrejon or Middle Palæocene on pages 269 and 270, and on this last page says it is the oldest known plesiadapid. It is of Middle Palæocene age, and is not older than the more surely plesiadapid *Pronothodectes*.

don" = *Eudolops*), then to a secondarily non-shearing or semi-shearing stage in which the tooth in question is not even homologous with its supposed structural ancestors ("*Polymastodon*" = *Tæniolabis*). Even aside from the fact that it includes members of three very different groups of animals in which the origin of shearing was demonstrably independent, this supposed structural sequence assumes that evolution has been reversed in a fundamental manner five different times, and assumes that closely similar or almost identical dentitions (e.g., *Parabderites* = *Abderites*, or *Metæpanorthus* = *Callomenus*) are separated in sequence by very dissimilar structural stages.

ADAPTATIONAL SIGNIFICANCE

Intricate convergence from such unlike origins must be correlated with function, and in this case, with food habits, since it concerns the dentition. Direct evidence, by study of living animals, is given only by the rat-kangaroos and particularly the genera *Bettongia*, *Hypsiprymnodon*, and *Æpyprymnus*, the only living animals with dentition of decidedly plagiaulacoid type.

Owen (1871, p. 97) says, "The many and large molar teeth and procumbent subscalpriform incisors associated with the trenchant premolars of Potoroos and Bettongs, show the kind of substance these were destined to cut. We know it to be tough, dry vegetable substances, such as the coarse grasses of the *Xanthorrhaea*, the tegument of the Cycadeous *Macrozamia*, root-fibres, etc." Semon (quoted in Brehm 1912, p. 193), says of *Æpyprymnus rufescens* "Erst nach Anbruch der Dunkelheit erhebt sie sich und äst Gräser, besonders aber Knollen und Wurzeln, die sie mit den scharfen Krallen der Vorderpfoten ausgräbt." Gilbert (also quoted by Brehm) cites the destructiveness of *Bettongia lesueuri* in gardens, where it eats all plants but especially peas and beans. Lucas and Le Souëf (1909) mention also that the rat-kangaroos come out at night to eat grass and roots. Wood Jones (1924) says that *Bettongia lesueuri* is dependent on succulent sandhill vegetation and lives in competitive community with the introduced rabbits. Lohr (1913) emphasizes the root-eating propensities of the rat-kangaroos, although it is clear that they are by no means exclusively rhizophagous and he notes fruit as a minor element in the diet. Authorities might be multiplied, but those given are typical.

It is to be concluded that the dentition of the rat-kangaroos is adapted to an exclusively vegetable diet, and to one in which woody or other coarse fibers, bark, roots, grass, and the like, predominate. The food is first secured by the incisors, not strictly by gnawing but rather by simple seizing, cut by the shearing teeth, and ground or crushed by the molars.

Although Owen (1871) and others held that they were carnivorous, most authorities are now agreed that the plagiaulacoids, proper, were herbivorous. Gidley (1909, p. 626) said, ". . . . as to whether they were insectivorous, herbivorous, or frugivorous there may still be some differences of opinion. I am inclined to consider them as frugivorous, since the incisors were well fitted for picking small fruits or berries, while the large cutting blades of the lower premolar were admirably adapted to cutting or slicing the rinds of tough-skinned berries, or to chopping up fleshy fruits held against the blunt-pointed premolars of the upper jaw." In my previous detailed analysis (1926, p. 246), I reached a similar conclusion: "We may also conclude that they were all herbivorous. . . . . The

various smaller forms based their diet on cycads, cones and nuts, and angiosperm fruits and seeds. . . . ." This conclusion still seems most probable.

The diet of polydolopids has been little discussed. Adaptively, they are so similar to multituberculates on one hand and rat-kangaroos on the other, that what is inferred regarding the former and known about the latter can be applied to them with little modification. The principal difference is that the molars, posterior to the shearing teeth, are not directly adapted to grinding as they are, *par excellence*, in the multituberculates (especially the later forms) and also to a considerable extent in the rat-kangaroos. In polydolopids these are, rather, multicuspid crushing teeth. Probably a somewhat more succulent diet is indicated, although it was one which wore the teeth rapidly, most specimens having the cusps truncated.

Carpodaptes (καρπός, fruit; δάπτης, eater) was so named by Matthew and Granger (1921) because of their inference to its habits. This inference seems quite justified, except that analogy would suggest that the shearing premolars were adapted for fruits with fibrous integuments and probably that bark and roots were other possible food sources. In *Carpodaptes* and *Carpolestes*, as in the multituberculates, the upper premolars suggest some difference of diet from the rat-kangaroos, and I believe this difference probably lay in the direction of a more frugivorous regimen, the unopposed premolar cusps being adapted to holding round seeds and fruits firmly. In these forms also the molars are not adapted to grinding so much as to crushing. I do not agree with Abel (1931, p. 327) that analogy with rat-kangaroos shows these to be terrestrial forms. The food habits were apparently not identical; they appear to be equally appropriate for terrestrial or for arboreal forms in *Carpolestes* and *Carpodaptes* (for they were hardly confined to roots for food in any case), and arboreal or terrestrial habits cannot be surely determined from the dentition.[5] The analogy is not perfect and perhaps here has been pushed too far.

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THE RACCOON—SOME MENTAL ATTRIBUTES

By Leon F. Whitney

In the February, 1931 issue of the Journal of Mammalogy, the author published some remarks about the "Raccoon and its Hunting." At that time he promised to make a further contribution concerning its mental characteristics.

The raccoon, being a night-prowling animal, is but little known, and the literature about him is often misleading. This is typified by the name, *Procyon lotor*, the washer. In my previous paper, I discussed the fact that the raccoon in a natural state does not wash the food he eats, or certainly not more than a very small part of it. I have sat for hours watching raccoons in an effort to discover just what the animal does which could have suggested its name. My conclusion is that the raccoon is a *feeler*. After having watched raccoons take food to the water troughs in their cages, one asks at once: do they take it there to wash it? No! The raccoon is a "dunker." He dunks his food, as a man dunks a doughnut. And as for washing it, he may move his paws over the surface to feel it, but he does not do this to wash it. Given food in a dry enclosure with no water present, he will feel it all over. Before eating food in the form of mash he will often rub it between his paws and when once he has satisfied himself that it is all right, he will continue to eat it by the handful without bothering to feel it.

While the raccoon has a good sense of smell, his sense of touch is developed to a very extraordinary degree. The stimulus received through his hands and fingers is very great compared with that of most other animals. Sometimes a raccoon will take nuts to the water pan in a pen and manipulate them under water, thus giving the impression that he is washing them. He seems to like to feel things in the water. Sometimes I have seen one sitting by the water pan just dangling a paw back and forth through the water.

I tried the simple experiment of letting a raccoon feel what he could not see, by putting a wide board against the wire at the bottom of the cage. Over this wire the raccoon had to reach. I put an assortment of nuts and other foods mixed with stones in a shallow box. The raccoon reached over the board, and sticking his arm out through the wire just as a man might reach for something, he felt the articles thoroughly and lifted out several nuts and apple parings. He left the stones alone until the last. The raccoons have pulled into their pens everything within reach, including leaves, sticks, roots and pebbles, but if food is

put there, they seem to take that first and to know it is desirable by the contacts of their delicate and dexterous fingers.

Sometimes several of the raccoons will crawl up the wire of the cages at the same time. These cages are all connected. If the wire be lightly touched every raccoon will feel the vibration and look around. On the other hand, if in the evening one is hammering on a board and making various other loud noises when they happen to be out, they never appear to be disturbed in the least. In the late afternoon when many of the raccoons have been out, lying listlessly about the pens, I have carted rocks to use as foundations of concrete floors. When loads of rocks were dumped from a steel wheelbarrow, even that clatter failed to make much impression upon the animals' serenity.

There was a good illustration of this, last year, when a litter of young ones was born. They were never observed unless the mother was out of the box. They were two weeks old and during that time there had been plenty of commotion and noise nearby, including the changing of several nest boxes, a process that necessitated hammering. The mother cared for her kittens well. Then one day a boy pushed a stick through the wire and poked her box so that it rocked back and forth, because as he said, "he liked to hear the little ones chirp." Following this disturbance, the female ate three of her young ones within a few hours. An effort was made to save the fourth, which she had already started to eat, but it soon died.

In short, the raccoon is not nearly as sensitive to noise as to vibration; his sense of touch is developed far more in proportion than any of his other faculties, at least when compared with our ordinary familiar mammals. This is what makes the raccoon stand out as very distinct from any other mammal of which the author knows. One has but to watch a raccoon eating or investigating with his sensitive paws or hands and one will immediately gain this impression.

Possibly this development has come about through its tree climbing propensities. Living high up in a tree where the wind roars and the thunder is louder, possibly a raccoon would need to be less sensitive to noise, and less wary for sound warnings. But he would need to be extremely sensitive to warnings through the sense of touch, and he is. If an enemy attempted to climb a tree in which he was living the fact must needs be transmitted to him; hence his development of this extraordinary power. Sometimes when hunting, my dogs have treed a raccoon in a tree too large to climb, and it seems impossible to induce him to look down at the flashlights so that his eyes may be seen and the

hunter may know where to shoot. When an incident of this kind occurs, the hunters pound on the tree trunk with a rock. This will almost always arouse the animal's curiosity and he will look to see what is happening.

The raccoon is not only dexterous with his hands but he often appears to do things that are indicative of a high order of intelligence. For example, I undertook to see what the behavior would be when I put a hungry raccoon in a cage with a wire bottom and placed food well out of reach of his paws beneath the cage. When the raccoon found he could not reach the food, he sat and looked at it for a while and later walked up and down. Then I took a little box and fastened a string to it and tied the string to the bottom of the cage. The raccoon at once reached out with both paws and dexterously drew the string up until he could catch hold of the bail across the top of the box and held this with one hand while with the other he reached in and took out the food, occasionally forgetting and dropping the basket when he used both hands to feel the food first. Next I placed a piece of liver in a small box on the ground three feet from a cage and attached a cord from the box to the wire of the cage. To the astonishment of the onlookers, the raccoon reached out and hauled in the box, hand over hand, as neatly as a man would draw up an object on a rope.

Nothing seems to have been written about the family instincts of the raccoon beyond the fact that the mother usually keeps her young ones with her during the first growing season. The attachment between the male and the female has apparently not been recorded. In my pens, I have been using two females and one male in each compartment. The matings are usually made at least a month before the copulation period.

Two years ago I did not take this precaution and shifted several around just at the height of the period, or during the month of February. The raccoon pen is 150 feet from the house but the family were often awakened by screams and chatterings that pierced the air. At that time the real reason for the noises was not known. The number of females that became pregnant was remarkably small. This year the matings were arranged in December. All during February and the latter half of January, almost the only noises that were heard were the males snarling back and forth at each other where their pens adjoined. This time all the females that were over a year old, and several yearlings became pregnant.

It was evident that when a female had become attached to a male

she did not want to be separated from him and would not copulate with strange males. In fact there comes to be a very strong attachment between the males and their mates, although they are not monogamous. They are polygamous but the polygamous instinct seems to reside in the male. In other words a male will mate with several females, and the female apparently will not mate with any male except the one to which she has become attached, probably by propinquity. So strong is the affection or attachment of a female for her male that she will do her utmost to reach him if she is separated from him.

One of the females mated earlier this year than was expected. She whelped three weeks before the arrival of her kittens was anticipated. As soon as I heard the chirping noise that the little ones make, I moved the male and the other female into separate pens so the mother could be alone. As soon as she looked out and found the other gone, she took a newly born young one in her mouth and began to crawl all around the pen. She walked restlessly up and down along the wire, although her mate was only on the other side where she could see him. But she would not be content until she was back with him or he with her. When he was put back temporarily to see what would happen, she growled at him and would not allow him in the nest box, but was contented as soon as she knew he was back in the run with her.

The raccoon seldom jumps, up or down. He can do so, but he prefers to climb. On different occasions I have seen them jump well up to the top of their nest boxes, a distance of two feet. I have seen them jump down, but this is unusual. In the woods I have seen them jump out of very high trees and get up and run. They hit the ground with a bump that sounds like a pillow landing, apparently entirely relaxed, and in an instant, as soon as they have become oriented they are on the run again. A friend and the author treed one that afterward proved to be pregnant, and within a month of parturition. She jumped out of a tree thirty or more feet from the ground, landed on her side, and started to run, but the dog caught her and held her until she could be put in a bag. The experience seemed not to have harmed her, for later on she had four kittens.

We often hear about the clean habits of the raccoon. It is clear when it has plenty of room. They will deposit their stools in one or at most two corners of their pen. The chances are, however, that when a pen is much smaller than four by twelve feet, and is occupied by three raccoons, they will tend to soil the pen more and more as the size is reduced. A pen four by six is too small for three raccoons. The author

experimented and found it best to use sloped cemented bottoms to the pens and in the larger pens these are always clean, but in the smaller pens they are dirty and littered up. The pens are six feet high.

The raccoon differs from the fox in that he chews his food. He does not gulp it like the dog. He takes plenty of time to chew, and he masticates most foods well. With hard shelled corn he often swallows it after splitting each kernel into six or eight pieces.

In the previous paper the author mentioned the items that he had found in stomachs of raccoons taken through the fall months. To this list several new items may be added. However, experience with raccoons in captivity and in the wild, shows that the animal will eat almost anything that is considered nutritious by man. This, of course, does not include condiments, and leafy vegetables are not particularly relished. Almost all animal forms will be eaten. To mention a few uncommon things: snakes are relished; worms, but not all woolly worms are eaten; the bark from roots of some trees or bushes; shell fish, snails, and even the flesh of its own species.

There have been several unpleasant experiences from cannibalism. Three small younsters have been pulled through the wire by males and killed and eaten. These were little fellows out exploring. They were small enough to crawl through the wire netting and across the top of the cage, over the pens where the males were. In another case a raccoon which had recovered from pneumonia was killed by those in the next pen and pulled through the wire and eaten. The last instance occurred while there were several uneaten chicken heads still in the pen.

One of the most pronounced characteristics of the raccoon in captivity is his greediness. Sometimes when food is put into two runs, a raccoon will not bother to eat the food in his own run but will try to reach through the wire and get that which is in his neighbor's run. After he feels he has pulled all that can be reached through the wire, he will go to eating, but usually not before, unless he is very hungry.

Having procured the food the raccoon is one of the most wasteful feeders among the mammals. Food must indeed have been plentiful for him in his native haunts. Instead of eating as most other animals will do, he must first examine as much as possible, and his curiosity is insatiable. Possibly his curiosity causes him to be so wasteful. Certain it is that curiosity is one of the major characteristics of the species.

All of these native attributes one sees in the raccoon in captivity. In the hunting of the animal, one sees other interesting characteristics. A raccoon can keep so still in a tree in the day time that often it takes

exceptionally good eyes to see him. And often a raccoon will use his powers of mimicry to most excellent advantage. The author recalls one instance that illustrates this point. The dogs treed a raccoon in the very early morning, just about dawn, over a mile away from the hunters, and it took some time to arrive at the tree. The animal could not be seen in the tree. The dogs were frantic. Every spot in the tree seemed visible and it would have been difficult for the smallest of animals to have escaped the eyes of the four hunters. Then finally, after fifteen minutes, one looked again at the great tree trunk and there not more than fifteen feet from the ground was the quarry. He had reached out as far as he could on both sides of him, and had thus stretched his body out to be very thin. He looked to be no more than 2 inches thick. He could easily have climbed up to the first limb but preferred to stay there looking like part of the tree. His protective coloration made it difficult indeed to detect him and he remained so still that we did not notice him. I have seen this sort of thing happen on several occasions, but never so deftly accomplished as at that time.

Probably the raccoon learns with great ease. Once one has taken a certain route to escape the pursuit of dogs, he will generally return to this avenue next time and always thereafter, but not necessarily as a habit. For example, in one place where the author has hunted a good deal there is a great ledge, and growing beside it is a large hemlock tree, in which a raccoon was treed one night about two years ago. I climbed the tree and came very close to the raccoon. Just as I was about to shoot, the raccoon ran out on a limb and off on to the top of the ledge. The next night I went to the same place and apparently ran the same raccoon. He made a turn in his trail, climbed the same hemlock and this time did not wait for anyone to follow but ran right out of the tree, down the back of the cliff, and into a ledge a hundred yards away, so eluding the dogs. A few nights later he was tried again, and this time one dog was held while the other started toward the hemlock tree. I ran with my dog, around the back of the ledge and waited; before long I heard the raccoon coming down off the ledge and I then loosed the dog. He chased the raccoon but lost him in the other ledge. Many tricks were tried to catch that raccoon but none was successful.

Another case that illustrates the point well is that of a raccoon that learned in one experience to take to the water. He ran into the lake once and found he had escaped that way. The next time he was pursued he did the same without a moment's hesitation. The next time a boat was obtained and two men were in it waiting out in the lake. When the raccoon went into the water he was caught.

Some raccoons will learn that to jump from a tree is the best means of escape, and they will often climb hemlocks where they can hide until a man gets well up the tree, then jump and get away if they can escape the dogs, which they usually do. This will go on until some hunter shoots the raccoon with a shot gun from the ground. However, with the great majority of uninitiated raccoons, they will go up a tree at the first signs of commotion, sit in the branches and watch the happenings below, unmindful of real danger; let a hunter shoot, or make all sorts of noise, and the raccoon is oblivious to it. But let a bullet strike the branch on which he sits and he will scurry for protection higher in the tree.

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ADDITIONAL NOTES ON THE MAMMALS OF SOUTHERN ARIZONA

By William Henry Burt

During the spring of 1931 the writer spent six weeks, April 23 to June 9, in southern Arizona, collecting and studying mammals. The primary purpose of the field work was to obtain comparative material to be used in connection with a report now in progress on the mammals of Sonora, Mexico. In the course of this field work some data on distribution and habits were obtained that seem worthy of record.

In his report on the faunal areas of southern Arizona, Swarth (1929) covered the territory from the Santa Rita Mountains eastward in Arizona. The present report covers the region from the Santa Rita Mountains westward to the Baboquivari Mountains, thereby supplementing Swarth's data. Five localities were visited as follows: Madera Canyon and Old Parker Ranch, west side of the Santa Rita Mountains; Continental, on Santa Cruz River, 26 miles south of Tucson; Santa Cruz River, two miles south of Tumacacori Mission; Piskorski Canyon, east side of the Atasco Mountains; Los Enciños Ranch, Baboquivari Mountains. The greater part of the time was spent at Continental and on the west side of the Santa Ritas, short visits of a few days each being made to the other localities.

I wish to express my thanks to the Arizona Fish and Game Commission, who granted permission to carry on the work, and to Mr. F. W. Taylor whose hospitality was enjoyed at Continental.

Myotis velifer velifer (J. A. Allen).—Cave Bat. This bat was fairly common along the Santa Cruz River where, in the evenings, many were seen flying low among the mesquites. Four were taken late in the evening of April 29 at Continental and one was taken two miles south of Tumacacori Mission, May 12. At about 6000 feet altitude, in Madera Canyon, Santa Rita Mountains, six males and one female were found, May 30, hanging in a clump far back in an old mine tunnel. As a consequence of a stream of cold water running through the tunnel the temperature was rather low where the bats were hanging. They were in a state of semitorpor, their bodies being noticeably cold to the touch. No other bats were seen in the tunnel.

Pipistrellus hesperus merriami (Dobson).—Merriam Bat. A female with two embryos in her uterus was taken on the Santa Cruz River, May 13. A male and a female were taken at 4500 feet altitude in the Atasco Mountains, May 20.

These bats have here been referred to the subspecies *merriami* because, to me, they are indistinguishable from specimens of *merriami* taken on the coast of California. In 1904 Elliot described what he supposed to be a new race, *apus*, from Providencia Mines, northeastern Sonora, Mexico. Through the courtesy of Director S. C. Simms and Dr. W. H. Osgood of the Field Museum I have been able to examine the type and three additional specimens of *apus* from Providencia Mines. There are also in the Dickey collection thirteen specimens from Saric, Sonora. The southern Arizona and northeastern Sonora specimens average slightly larger than California specimens of *merriami*, but the extreme measurements are about the same and the slight average difference loses its value. In the original description of *apus* the only character given by Elliot (1904, p. 269) that might distinguish that race from *merriami* is the larger foot. For the length of the foot Elliot gives 6.3 mm. which falls between the extremes of the Saric specimens (5.0 mm. to 6.5 mm.) as well as those of *merriami* from California (5.0 mm. to 6.5 mm., H. W. Grinnell, 1918, p. 313), being slightly larger than those of *hesperus* (5.0 mm. to 6.0 mm., H. W. Grinnell, 1918, p. 307). In coloration the southern Arizona and northeastern Sonora specimens fall in with *merriami*, being buffy both above and below instead of whitish as is the case in *hesperus*. In the Dickey collection are also two specimens from Paradox, Montrose County, Colorado, which fit in, in their dark coloration, with *merriami*. It seems to me that unless characters other than those given by Elliot, and other than those which I have been able to discern, are found for the *Pipistrellus* of northeastern Sonora, Elliot's name *apus* must be placed in synonomy under *Pipistrellus hesperus merriami* (Dobson). We then have a range for *merriami* similar to that given for *Myotis californicus californicus* by Miller and Allen (1928, p. 149), with the metropolis of the race *hesperus* in the Great Basin area as is the case with *Myotis californicus pallidus*. Specimens of *hesperus* from near Las Vegas, Nevada, and Death Valley, California, show the extreme condition of pallor found in the subspecies.

Eptesicus fuscus pallidus Young.—Pallid Brown Bat. One adult male was taken at 4500 feet altitude in the Atasco Mountains, May 20. It was flying above the oaks in the bottom of a canyon; several others were seen at the time. In referring the one specimen to *pallidus* I have followed Allen in his recent paper (1933).

Bassariscus astutus arizonensis Goldman.—Arizona Ring-tailed Cat. Ring-

tailed cats were reported to be common in Madera Canyon; no specimens were taken and no signs of them were seen during our short stay there.

Mephitis macroura milleri Mearns.—Hooded Skunk. The desiccated remains of a skunk of this species were found two miles south of Tumacacori Mission on the Santa Cruz River. The skin was unimpaired. Another skunk, in a similar condition, was found in a canyon in the Atasco Mountains and a third in Thomas Canyon, Baboquivari Mountains.

Mephitis estor Merriam.—Arizona Skunk. Two females were trapped, May 20 and 22, in Piskorski Canyon, Atasco Mountains. One of them had four embryos in her uterus; both stomachs contained insect remains. Swarth (1929, p. 347) reported the taking of a specimen of *M. estor* at the mouth of Stone Cabin Canyon, Santa Rita Mountains.

Urocyon cinereoargenteus scottii Mearns.—Arizona Gray Fox. An adult male was taken in Piskorski Canyon, Atasco Mountains, May 22. The species apparently is common in southern Arizona.

Canis mearnsi Merriam.—Mearns Coyote. Five skeletons were salvaged from a lot that had been thrown along the side of a road on Los Enciños Ranch in the Baboquivari Mountain district. Coyotes were common throughout the area covered by us.

Felis concolor subsp.—Mountain Lion. Mountain lions, we were told, are no longer common in southern Arizona. When an occasional lion is reported the cattlemen turn out in full force and, with the aid of a lion hunter and his hounds, usually get it. As a consequence the few lions remaining in this territory are in danger of being exterminated. While we were in the Atasco Mountains a professional lion hunter with his pack of hounds came up the Canyon looking vainly for a lion that had been reported in the region.

Lynx rufus baileyi Merriam.—Bobcat. Bobcats were reported to be common in Madera Canyon. Two individuals were taken there, May 29 and 31, respectively.

Citellus grammurus grammurus (Say).—Rock Squirrel. An adult female, suckling young, was taken at Continental, in the Lower Sonoran Zone, April 30. This species is normally found in the Upper Sonoran Zone. They are common in Madera Canyon, from which place Swarth (1929, p. 348) reported them. Rock squirrels were common also in the Baboquivari Mountains, but none were taken there by us.

Citellus tereticaudus neglectus (Merriam).—Round-tailed Ground Squirrel. This species was common over much of the low desert. Two females, one with active mammae, were taken at Continental, April 23 and 27. Young squirrels were seen on the west slope of the Santa Rita Mountains, June 6 and 9; one adult and two young were taken at this time. On June 9 an adult female was seen at the entrance of a burrow around which, within a radius of 50 feet, were five young, apparently her progeny. The young, being less cautious than the adult, remained farther away from the safety retreats when danger was sensed, but when the adult gave the danger signal they all crouched down and remained quiet.

Swarth (1929, p. 349), in placing his southern Arizona specimens in the subspecies *neglectus* apparently considered *Citellus tereticaudus arizonae* Grinnell to be a synonym of *neglectus*. He gave no reason for not recognizing Grinnell's race *arizonae*, but later, in conversation, Mr. Swarth told me that in his compari-

sons he could find no distinguishing characters for *arizonae*. Measurements of *neglectus* and "*arizonae*," furnished me by Mr. A. H. Howell, and measurements of specimens in the Dickey collection from near Tucson, Arizona, indicate that there is no appreciable size difference which might be used as a character.

Ammospermophilus harrisii (Audubon and Bachman).—Gray-tailed Antelope Squirrel. Two males were taken, one at Continental and the other on the west slope of the Santa Ritas. Very few others were seen.

Sciurus arizonensis arizonensis Coues.—Arizona Gray Squirrel. We saw a number of these squirrels in the Santa Ritas. At 6000 feet altitude, along a small stream, two males were taken May 29, three, May 30, and three males and a female, May 31. All were taken within a radius of 25 yards. On the last date five males (?) were seen chasing a female through the trees, at least the head squirrel was a female and three of the others were males. In this spot, in three days, one female and nine males were taken and two others, probably males, were seen. Judging from the condition of her uterus and mammary glands, the female had recently given birth to young. It appeared as though the males had concentrated in this spot in pursuit of the female.

In his description of *catalinae*, Doutt (1931, pp. 271–273) referred one specimen from the Santa Rita Mountains to his newly described form, although he says (p. 272) that it "can be separated readily from any of the other five specimens [from the Catalina Mountains] by its more rufous crown patch." There is considerable variation in the coloration of the ten specimens at hand from the Santa Rita Mountains, all but one of which still have the old worn pelage. The one specimen (no. 18,902), which has the new pelage back nearly to the rump region, is distinctly russet between the ears and from the mid-dorsal region to the rump. Of the other nine specimens one (no. 18,903) is gray from head to rump, one (no. 18,916) is gray over the shoulder region with a russet patch on its head and a russet streak from the middle of the back down over the rump to the base of the tail, and the other seven have the russet continuous from the head to the base of the tail—comparable to a specimen of *arizonensis* from the Sierra Ancha Mountains.

To sum up the above; one specimen has the characters of *huachuca*, seven those of *arizonensis*, and two intermediate between *arizonensis* and *catalinae* as characterized by Doutt. On geographic grounds alone the Santa Rita specimens should be closer to *huachuca* than to *arizonensis*, and if *catalinae* is distinguishable the Santa Rita squirrels should be closer to that form than to either *huachuca* or *arizonensis*, but actually they seem to be intermediate between *arizonensis* and *catalinae*, with the preponderance toward *arizonensis*.

Thomomys fulvus modicus Goldman.—Pocket Gopher. This species was abundant along the Santa Cruz River near Tumacacori Mission. The ranchers here told us that pocket gophers had to be fought continually, as they did considerable damage to the irrigation ditches. From May 12 to 16, twenty gophers, eight males and twelve females, were taken. The soil here was sandy. Six of the females were suckling young and one contained three small embryos in her uterus.

The pocket gophers of this region offer a most interesting and at the same time puzzling problem in distribution. This form is found to be common on the Santa Cruz River at Tucson. Going south up the river, one runs out of pocket gopher

territory. At Continental, 26 miles south of Tucson, where conditions seem to be as favorable as one could expect for pocket gophers, there are none. Here there are large fields of alfalfa under irrigation, sandy soil, and other conditions that would seem to be ideal for a gopher population. The foreman of the Continental Ranch informed me that he had never seen a sign of a gopher there. From Continental we pass 19 miles farther up the river to Tumacacori Mission and here again we find gophers in abundance. We also find gophers, but of a different species, in the Santa Rita Mountains. I have no explanation for their absence along the Santa Cruz River between Tucson and Tumacacori Mission.

Thomomys burti Huey.—Santa Rita Mountains Pocket Gopher. These gophers were reported from Madera Canyon under the name *intermedius* by Swarth (1929, p. 351), five having been taken there. We found their workings to be rather common along the canyon bottoms at an altitude of 6,000 feet and above. They were found in black, moist soil along the streams and on the steep slopes. Eleven specimens were taken, two of which were young. Even these young individuals display the dark coloration so characteristic of the race.

Gophers from the lower edge of the oaks, about 5,000 feet altitude, although similar in size, differ strikingly in coloration from the Madera Canyon specimens. These gophers, from Old Parker Ranch (Picketts Ranch on U. S. G. S. topographic map, Patagonia Quadrangle, edition of August, 1905), are found under ecologic conditions quite different from those of Madera Canyon. The soil here is hard, dry, and rocky, and of a markedly lighter coloration. None of the Parker Ranch gophers approach any of the specimens from Madera Canyon in coloration; even the young are easily distinguished, a condition not usually met with in closely related gophers. In the skulls there is very little difference, except that in the Parker Ranch gophers, the premaxillae project posteriorly farther beyond the nasals. Because of the differences in characters and in habitats of the two colonies of gophers, although they inhabit the same mountain range and are separated by a distance of only eight miles and 1,000 feet altitude, the Parker Ranch gophers might be regarded as subspecifically distinct, but until more data can be obtained on the local distribution of the gophers of the Santa Ritas, I prefer to treat them as a local variation of typical *burti*.

Perognathus flavus flavus Baird.—Baird Pocket Mouse. These pocket mice, in addition to three other species, were found commonly at Continental, where ten females and five males were taken. One male was taken near Tumacacori Mission and another in the Baboquivari Mountains. Swarth (1929, p. 353) reports two specimens from Stone Cabin Canyon.

The abundance of this species in a locality may not be appreciated from one or two trapping-nights. This was shown at Continental where in a line of traps left in the same place for five successive nights the catch of *flavus* increased after the first night and that of the other species decreased. A string of 90 traps set along a fence row between an alfalfa field and an abandoned field that had grown up to weeds was left in the same place for the five nights May 4 to 8 inclusive. On the night of May 7 the traps were not baited so it is omitted from the following account. The catch for the four nights, May, 4, 5, 6, and 8 was as follows: *Dipodomys*—16, 6, 2, 0; *Perognathus p. pricei*—14, 5, 0, 2; *Peromyscus*—8, 2, 2, 0; *Onychomys*—4, 3, 0, 0; *Reithrodontomys*—4, 0, 0, 0; *Mus*—1, 2, 0, 0; *Perognathus f. flavus*—1, 2, 6, 5. There was thus a marked decrease in the number of speci-

mens caught after the first night in all but *Mus* and *P. f. flavus*, the latter giving the largest returns on the last two nights.

Perognathus amplus taylori Goldman.—Taylor Pocket Mouse. One specimen was taken in a sandy wash at Continental, April 25. Swarth (1929, p. 355), reports *amplus* from the Santa Rita Range Reserve, which was later designated as the type locality of *taylori* by Goldman (1932).

Perognathus baileyi baileyi Merriam.—Bailey Pocket Mouse. Three specimens were taken at Continental; one female, collected April 25, contained four embryos. Four more specimens were taken on the east slope of the Baboquivari Mountains. A female taken here May 25 contained three embryos.

Perognathus penicillatus pricei Allen.—Price Pocket Mouse. This species was found to be common at Continental, especially along the banks of the Santa Cruz River, where most of those secured by us were taken. They were also taken near Tumacacori Mission on the Santa Cruz River. Two females taken April 24 contained respectively, four and five embryos.

Dipodomys spectabilis spectabilis Merriam.—Banner-tailed Kangaroo Rat. This species was taken on the Santa Rita Range Reserve, at Continental, and in the Baboquivari Mountains. For a detailed account of the natural history of this species, see Vorhies and Taylor (1922).

Dipodomys merriami merriami Mearns.—Merriam Kangaroo Rat. This species was taken on the Santa Rita Range Reserve, at Continental, Tumacacori Mission, and in the Baboquivari Mountains. Three females taken at Continental, April 26, had the mammary glands active. One of the females (no. 18708) had commenced to molt, the molt line being slightly back of the ears; the top of the head has the new pelage.

Dipodomys ordii ordii Woodhouse.—Ord Kangaroo Rat. Swarth (1929) reports this species only from his "Eastern Plains Area," near Patagonia. We found it common at Continental and Tumacacori Mission, and one specimen was taken as far west as the Baboquivari Mountains. At Continental these kangaroo rats were found to inhabit chiefly the areas along the river where the soil was softer and the vegetation was more dense than that away from the river. A female taken April 28 was suckling young, another taken May 4 contained four embryos, and a third female taken May 13 was also suckling young.

Onychomys torridus torridus (Coues).—Grasshopper Mouse. Grasshopper mice were found to be common along the Santa Cruz River at Continental. They were taken also near Tumacacori Mission and on the Santa Rita Range Reserve. Three immature individuals were taken, April 24 and 25, at Continental. From April 28 to May 4, females either with embryos or suckling young were taken; one contained three embryos, two contained four each, one five, and three were suckling young.

Reithrodontomys megalotis megalotis (Baird).—Desert Harvest Mouse. A male was taken at Continental, May 4. This species is apparently rare in this region.

Reithrodontomys fulvescens fulvescens Allen.—Sonora Harvest Mouse. Three males and two females were taken at Continental and one male near Tumacacori Mission. There is also in the Dickey collection a specimen (no. 6963) from Phoenix, Arizona. The two species, *megalotis* and *fulvescens*, occur together here in southern Arizona, where they were taken in the same trap line.

This extends the known range of the species north and west nearly 300 miles from the northern limit as given by Howell (1914, p. 44), who reported it from Oposura and Providencia Mines, Sonora, Mexico.

Peromyscus eremicus eremicus (Baird).—Desert Mouse. This species was taken at Continental and near Tumacacori Mission. A female taken May 2 contained three embryos in the left horn of her uterus. Immature individuals in the gray juvenile pelage were taken between April 28 and May 14; one of these (no. 18,769), just getting the adult pelage, contained three embryos. Three of the four adults have indications of buff pectoral spots, a character attributed to certain specimens of *anthonyi* by Osgood (1909); otherwise they are much closer to specimens from Bard, Imperial County, California, than to specimens from southern Sonora, Mexico.

Peromyscus maniculatus sonoriensis (Le Conte).—Sonora White-footed Mouse. Three males of this species were taken at Continental in the same trap line with *P. eremicus* and *P. leucopus arizonae* (Allen). They were taken along the Santa Cruz River, but apparently were not common there.

Peromyscus leucopus arizonae (Allen).—Arizona White-footed Mouse. Swarth (1929, p. 283) records this species only from the "Eastern Plains Area," none having been taken by his party west of the Santa Rita Mountains. We found them along the Santa Cruz River at Continental, the only locality at which they were taken; four specimens were preserved.

Peromyscus boylii rowleyi (Allen).—Rowley White-footed Mouse. This was the most common species of *Peromyscus* encountered by us. It was taken in the Santa Rita Mountains, Atasco Mountains, and near Tumacacori Mission. Immature individuals were taken May 10 and 20. Females that were suckling young were taken May 10, 14, and 20. Another female taken May 14 contained four embryos.

This species was found chiefly in rocky situations high up in the mountains, but the four specimens taken near Tumacacori Mission were near brush piles along the river bottom, altitude 3,300 feet.

Sigmodon hispidus cienegae A. B. Howell.—Cienega Cotton Rat. Cotton rats were common along the irrigation ditches at Continental. Seven females taken from May 1 to 8 were all either suckling young or contained embryos. Six of them contained embryos as follows: 17, 13, 12, 11, 11, and 8. The number of mammae in the seven females at hand varies from 10 to 12, five of the seven having 12 each, the other two 10 each. Two young individuals were caught in a single mouse trap May 5; they were side by side, apparently feeding on the bait at the time they were caught. This species breeds at least from early May to late September. Swarth (1929, p. 363) reports the taking of two females on September 21 and 23, respectively; one contained 12, the other 14 embryos.

Neotoma albigula albigula Hartley.—White-throated Wood Rat. Wood rats of this species were found commonly at Continental, in the Santa Rita Mountains, and in the Baboquivari Mountains. Their nests were usually built beneath cactus or brush. In Madera Canyon one was caught beneath a cabin in which we were staying; here they had nests along the rock cliffs and beneath boulders. A female collected at Continental, April 24, contained three embryos, 30 mm. in length.

Lepus alleni alleni Mearns.—Allen Jack-rabbit. These large jack-rabbits

were common at Continental, on the Santa Rita Range Reserve, and near the south base of the Baboquivari Mountains. A female taken April 23 was suckling young; young jack-rabbits from one-third to one-half grown were seen abroad at this time. For a more detailed account of this species, see Swarth (1929, pp. 364–367).

Lepus californicus eremicus Allen.—Arizona Jack-rabbit. A common species at all of the localities visited, except in the timbered regions of the Santa Rita and Atasco Mountains.

Sylvilagus floridanus holzneri (Mearns).—Holzner Cottontail. An adult female was taken on a grassy ridge in the Atasco Mountains May 21. No others were seen. This is apparently near the northwest limit of the range of the species. It has been previously reported from the Huachuca and Chiricahua Mountains by Nelson (1909, p. 180). The one specimen was taken at the lower edge of the Upper Sonoran Life Zone.

Sylvilagus audubonii arizonae (Allen).—Arizona Cottontail. This species was fairly common in the lowlands, especially where there were growths of mesquite and brush.

Pecari angulatus sonoriensis (Mearns).—Sonora Peccary. Peccaries were reported to be present in the Atasco and Baboquivari Mountains, and were reported to come down into the lowlands. The foreman at the Continental Ranch said that one was caught near the Santa Cruz River at Continental a number of years ago. On Los Enciños Ranch we were told that the cowboys occasionally encountered them while riding the range. Although we spent a good deal of time looking for them we saw none; however, we did see their droppings and places where they had been feeding among the oaks in the Baboquivari Mountains.

Odocoileus couesi (Coues and Yarrow).—Coues White-tailed Deer. This species was common in the Santa Rita Mountains. Nearly every day that we went up Madera Canyon we would see from one to five deer. Their tracks were numerous back into an old mine tunnel in Madera Canyon where, on June 2, as Mr. van Rossem was approaching the mouth of the tunnel, he heard something coming out with a rush. As he paused for a moment a buck and doe appeared at the mouth of the tunnel. The buck was just beginning to get his new antlers, the nubs of which were about two inches long.

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DIFFERENTIAL GROWTH IN THE CRANIA OF MATURE MICE

BY C. V. GREEN

It is well known that the skull of a mammal undergoes marked changes in proportion between birth and maturity. It is less well known, although it has been pointed out on several occasions, that even among adults of a single race differences in absolute size may be accompanied by differences in proportions. Castle (1932), for example, has stated that in rabbits the skull steadily becomes more slender, relatively, as the absolute size increases. Allen (1894) has shown the same situation prevailing in a species of *Neotoma*.

Such changes may hold not only for individuals within a species but for different species within a genus, as Huxley (1932) so clearly demonstrated. Thus, the same fundamental law of heterogonic growth in the various dimensions of the skull may act both inter- and intra-specifically. Castle (1932) remarked on this tendency among different species of rabbits and horses. The danger in using mere indices, without further analysis, as taxonomic criteria, especially for forms differing in absolute size, is at once apparent.

The skeletons of at least some rodents, including the rat, *Rattus norvegicus albinus* (Strong, 1925), and the Microtinae (Hinton, 1926)

apparently continue to grow throughout life, although at a very slow rate in adults, and, as a result, are probably constantly changing their proportions. Dice (1932) has presented evidence that skulls of *Peromyscus maniculatus bairdii* increase slightly in length after the animals are one year old. Since the changes taking place after maturity are ordinarily so slight, they have usually been considered by taxonomists as affecting little, if at all, the validity of indices as specific or subspecific characters. Despite the fact that there is always some variation in absolute size within a population of mature individuals of a form, proportions have been deemed genetic and but little influenced by variations in length after the mammal has attained approximately final size.

In a craniometric study, the writer (1932) brought out differences, both absolute and relative, in cranial dimensions present in two species of mice and their F_1 and back-cross hybrids. The evidence indicated that the differences in proportion (relative measurements) characteristic of the two forms were probably genetic, although the mode of inheritance was not at all clear. Since the age and ancestry of all animals involved are known, these skulls offer excellent material for studying differential growth in mature animals.

MATERIAL AND METHODS

The two species of mice comprised races of *Mus bactrianus* and *Mus musculus*. The *bactrianus* were descendants of wild mice captured near Peiping, China, and brought to the United States in 1926. They are small, white-bellied murids with an average weight but little more than half that of our *Mus musculus* strain. The two species differ morphologically in several particulars; the former, for example, possesses approximately five fewer caudal vertebrae than the latter. In color, *bactrianus* is intense, white-bellied black agouti (DBA^w).

The *musculus* race used was the Little inbred strain of dilute, brown non-agouti (dba). It mates freely with the smaller species, producing hybrids of which both sexes are fertile.

The F_1 hybrids were from *musculus* females by *bactrianus* males, while the back-cross animals were produced by mating F_1 males of this type to *musculus* females.

The skulls used in this investigation were those employed in the craniometric study cited above. Every mouse had attained or surpassed an age of 181 days before it was killed. This was intended to insure the inclusion only of adult animals which had attained approximately final size. Although the skulls may still have been growing at a very slow rate it is probable that most of the variation in size within a single race is due to the practical cessation of growth at different end points rather than by the death of the animal while growth was yet actively underway. Regardless of their exact explanation, it seems logical to assume that the variations in size represent stages in growth in the skulls of mature mice.

The following dimensions were measured by the writer with vernier calipers registering in tenths of a millimeter: length, breadth, height, zygomatic width, height of rostrum, width outside molars and interorbital width. These measurements have been described in an earlier paper (Green, 1932), so detailed descriptions are unnecessary here.

In addition, the cranial capacity was determined by filling the braincase with mercury, which was then weighed.

The relative value of a dimension was obtained by dividing the dimension by the length of the skull and is expressed by percentage.

ABSOLUTE MEASUREMENTS

The craniometric study presented the mean absolute values of the several dimensions. In every character, *musculus* significantly exceeds *bactrianus* with but little overlapping. The F_1 skulls equal or exceed the larger parent race in length and cranial capacity but are intermediate in other measurements. In general, females tend to exceed males in all dimensions.

RELATIVE MEASUREMENTS

The same study also gave the mean relative values for seven cranial dimensions. Here some marked differences are found in the two species. In particular, rostral height, interorbital width, and cranial capacity are relatively much greater in *musculus* than in *bactrianus*. The F_1 and back-cross means are close to those of *bactrianus* in the first two measurements but similar to *musculus* in cranial capacity. In other dimensions, the hybrids have a lower value than either parent species. The relative measurements disclose no significant sex differences.

A consideration of the means leads to the question of the relation between absolute skull length and relative dimensions; in particular, relative rostral height, interorbital width, and cranial capacity, since the absolute skull length is greater in *musculus* than in *bactrianus*. The sign of the correlation between absolute length and a relative measurement should show the trend of that relationship. If relative breadth, for example, tends in general to decrease with increased length, there should be a distinct negative correlation, both inter- and intraspecifically, as pointed out by Huxley (1932). If, on the contrary, relative breadth tends to increase, the coefficient of correlation should be positive. The strength of the correlation should indicate roughly the degree to which relative breadth is altered by increased absolute length.

Computations of the correlation coefficients between skull length and the relative dimensions for each of the different types of matings with the sexes considered separately disclosed fluctuating sex differences. Since only one—length and relative breadth in the F_1's—was significant it is probably justifiable to treat the sexes combined. The results are shown in table 1. One female *bactrianus* skull was abnormally low and narrow, and was omitted in correlations involving relative breadth, relative height and relative cranial capacity.

Relative breadth reveals a negative correlation with absolute length, significant in every type of mating. The coefficient varies from $-.438$ in *bactrianus* to $-.683$ in *musculus* although this difference is not significant. All classes combined likewise give a high figure so it is obvious that breadth of brain case decreases proportionately as skull length increases, not only intra- but inter-specifi-

TABLE 1

Correlations of skull length with relative dimensions

ABSOLUTE SKULL LENGTH	NUMBER	TOTAL (♂+♀)	NUMBER	BACTRIANUS (♂+♀)	NUMBER	MUSCULUS (♂+♀)	NUMBER	F_1 (♂+♀)	NUMBER	BACK-CROSS (♂+♀)
Relative breadth ..... r =	344	−.595±.024	60	−.438±.070	99	−.683±.036	67	−.569±.056	118	−.600±.040
Relative height ..... r =	344	−.345±.032	60	−.209±.083	99	−.536±.048	67	−.011±.082	118	−.601±.040
Relative zygomatic width ..... r =	345	−.398±.031	61	−.276±.080	99	−.313±.061	67	−.428±.067	118	−.187±.060
Relative height of rostrum ..... r =	345	+.182±.035	61	+.055±.086	99	+.090±.067	67	+.145±.081	118	−.200±.060
Relative interorbital width ..... r =	345	−.167±.035	61	−.314±.078	99	−.335±.060	67	−.237±.078	118	−.553±.043
Relative width outside molars ..... r =	345	−.464±.028	61	−.262±.080	99	−.295±.062	67	−.160±.080	118	−.422±.051
Relative cranial capacity ..... r =	344	+.476±.028	60	+.351±.076	99	+.023±.068	67	+.420±.068	118	+.280±.057

TABLE 2

Heterogony formulae of cranial dimensions

y = dimension; x = length

	BACTRIANUS	MUSCULUS	F_1	BACK-CROSS
Breadth	$y = 2.3102x^{.47}$	$y = 3.9811x^{.30}$	$y = 2.2299x^{.49}$	$y = 3.2860x^{.35}$
Height	$y = .9197x^{.63}$	$y = 2.6102x^{.30}$	$y = .2044x^{1.11}$	$y = 2.6219x^{.39}$
Zygomatic width	$y = 1.2856x^{.71}$	$y = .9623x^{.81}$	$y = 1.1721x^{.74}$	$y = .8913x^{.83}$
Height of rostrum	$y = .1954x^{.96}$	$y = .1212x^{1.14}$	$y = .0574x^{1.36}$	$y = .2610x^{.87}$
Width outside molars	$y = .4707x^{.74}$	$y = .5412x^{.70}$	$y = .2395x^{.95}$	$y = .8913x^{.53}$
Interorbital width	$y = 1.4576x^{.39}$	$y = .4299x^{.72}$	$y = .3290x^{.78}$	$y = 2.6219x^{.74}$
Cranial capacity	$y = .0180x^{1.85}$	$y = .1647x^{1.13}$	$y = .0049x^{2.27}$	$y = .0825x^{1.36}$

cally as well, insofar as our data are concerned. This tendency apparently extends widely among mammals.

Relative height also tends to decrease as length increases, although the trend is not so marked as in the preceding dimension since the correlation is significantly negative in neither *bactrianus* nor the F_1 hybrids. In fact, in the latter class the coefficient is only $-.011$. The coefficients of the two species again do not differ in a certainly significant degree. Allen (1894) encountered a similar trend in *Neotoma* if the measurements he gives for three examples may be taken as a representative sample.

A negative correlation, constant but not so strongly marked as in relative breadth, exists between zygomatic width and skull length. In neither *bactrianus* nor the back-cross is the coefficient certainly significant since it is but 3.5 and 3.1 times its probable error, respectively, in the two classes. Although the value ranges from $-.428$ for the F_1's to $-.187$ in the back-cross, the difference between the two extremes probably lacks significance.

Relative rostral height shows a slight and fluctuating correlation with absolute length. Only in the total group is it significant where, because of the large number, the probable error is small. The sign is positive in all classes except the backcross. The height of rostrum is significantly less, proportionately, in *bactrianus* than in *musculus*. Since there is but little relationship between absolute size of skull and this relative character, the differences between the two species are probably genetic and characteristic of the races.

A consistent, although for the most part not very marked, negative correlation is present between relative interorbital width and skull length. Only in the F_1 generation is it possibly not significant since it is but slightly greater than three times its probable error. The interorbital region is relatively narrower in *bactrianus* than in *musculus*. Skulls of the former species are absolutely shorter than those of the latter, and since longer skulls tend to be relatively narrower interorbitally than shorter ones, the proportionately lesser interorbital width of *bactrianus* must be genetic and not a function of absolute size differences.

Relative width outside molars, in agreement with most of the other dimensions thus far considered, tends to decrease as the skull increases in length. The correlation coefficient is least marked in *bactrianus* and the F_1's where it is but 3.3 and 2.0 times its probable error, respectively.

Relative cranial capacity, on the contrary, tends to increase with skull length. The coefficient of correlation is positive in sign throughout although so slight in *musculus* as to be of no significance. Aside from this one class, however, the trend is consistent both inter- and intra-specifically. Thus, the relatively greater cranial capacity of *musculus* over *bactrianus* may be partly a function of augmented absolute size and not entirely a specific characteristic. Dubois (1922) found that the large species of the genus always has less brain weight in ratio to the body weight than the small species. This is probably the case for our two species of mice but with skull length as the criterion of size the opposite appears to hold true.

MATHEMATICAL ANALYSIS

Since the several relative measurements obviously vary as absolute length increases the question naturally arises as to whether the various dimensions of

the skull follow the simple heterogony formula in relation to length. The formula is $y = bx^k$; y being the dimension, x the length while b and k are constants. If the logarithms of skull length give a straight line when plotted against the logarithms of the mean dimensional values for the length classes we may conclude that such a formula applies. When the several dimensions are so plotted they do approximate straight lines. It may be doubted whether, if the regressions of the relative dimensions on absolute length are linear as assumed in the computation of correlation coefficients, the absolute values of a dimension and length would give an exponential curve. The correlation coefficients, however, were computed only to indicate the trends and not to show the exact relationships. Moreover, the growth coefficients (values of k) are for the most part rather low, as will be observed below, so for such short ranges of values as present in the cranial dimensions, the curve of best fit in many cases is much like a straight line. We are, therefore, probably justified in computing the simple heterogony constants as a means of showing more clearly the rate of change in the several dimensions as skull length increases.

Table 2 gives the heterogony formulae, obtained by the method of least squares, for the cranial dimensions investigated while figure 1 presents the k values graphically. The computations are based on length classes containing six or more skulls.

The growth coefficient (k) of breadth varies from .30 in *musculus* to .49 in the F_1 hybrids, thus demonstrating distinct negative heterogony in all classes. Mature *bactrianus* skulls with k equalling .47 are apparently increasing in breadth relatively more rapidly than the larger species. The F_1 exponent is only a little higher than that of *bactrianus* while the back-cross figure lies between those of F_1 and *musculus*, but nearer the latter.

Height likewise presents evidence of negative heterogony in *bactrianus*, *musculus* and back-cross classes. The F_1 generation, in the contrary, seems to be increasing in height relatively a little more rapidly than in length, with a growth coefficient of 1.11, thus manifesting positive heterogony to a slight degree. Again, the *bactrianus* value is higher than the *musculus* with the F_1 hybrids greatly exceeding either.

Zygomatic width uniformly shows negative heterogony. Here the range is small with extremes of .71 in *bactrianus* to .83 in the back-cross.

Height of rostrum in both species appears to be not far from isogonic in its relation to skull length. The growth coefficient of *bactrianus* is .96; that of *musculus* is 1.4. As in breadth and height, the F_1 rises (1.36) while the back-cross falls, in this dimension to .87.

Width outside molars, in general, seemingly increases relatively more slowly than cranial length. In the first generation hybrids, however, the relation between the two is approximately isogonic, with k equalling .95.

In interorbital width, although all four classes manifest negative heterogony, the growth coefficient of *musculus* (.73) greatly exceeds that of *bactrianus* (.29). Once more, the F_1 figure (.78) is greater than any other with the back-cross (.74) very near to *musculus*.

Cranial capacity discloses a condition differing from the others. In every class it increases relatively more rapidly than skull length. *Bactrianus* with an exponent of 1.85 exceeds *musculus* (1.13). F_1 is highest with a value of 2.27 with the back-cross dropping back towards *musculus* with a growth coefficient of 1.36.

A perusal of figure 1 reveals an interesting situation. The growth coefficient is higher in the F_1's than in any of the other three classes for all dimensions excepting zygomatic width. In this measurement, all four values of k are very close together. The odds against the chance possibility of the F_1 coefficient being

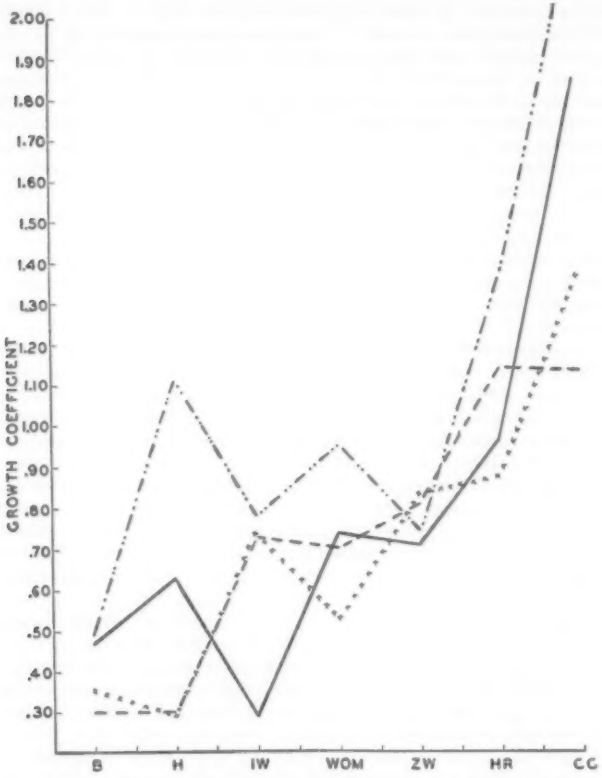

FIG. 1. GROWTH COEFFICIENTS OF CRANIAL DIMENSIONS

B, Breadth; H, Height; IW, Interorbital width; WOM, Width outside molars; ZW, Zygomatic width; HR, Height of rostrum; CC, Cranial capacity. ——— *bactrianus*; — — — *musculus*; — · · — · · — F_1; x x x x back-cross.

highest in as many as six of the seven dimensions are about 744 to 1, as shown by the expansion of the binomial $(1/4 + 3/4)^7$. It seems quite possible that heterosis may be manifesting itself by continuing differentiation longer and/or at a higher rate in the F_1 hybrids than in the parent species.

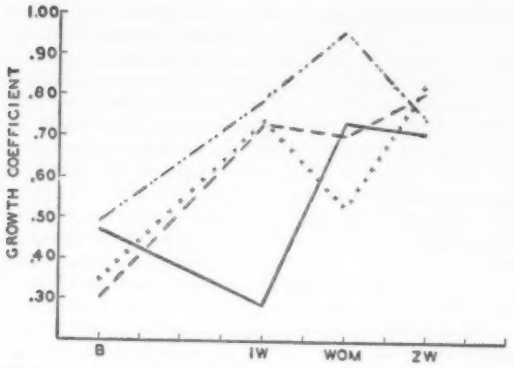

FIG. 2. RELATION OF GROWTH COEFFICIENTS IN HORIZONTAL DIMENSIONS B, breadth; IW, interorbital width; WOM, Width outside molars; ZW, zygomatic width. ——— *bactrianus*; — — — *musculus*; —·—·—·— F_1; x x x x back-cross.

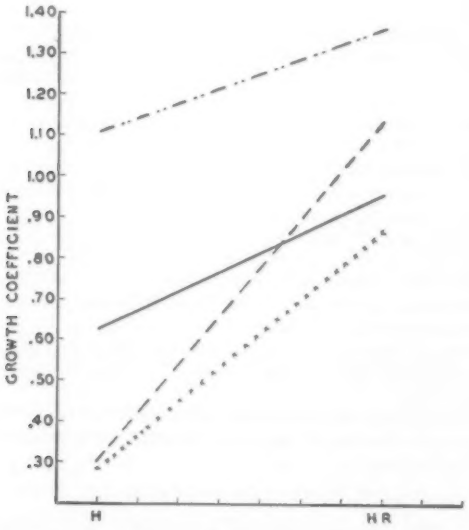

FIG. 3. RELATION OF GROWTH COEFFICIENTS IN VERTICAL DIMENSIONS H, Height of braincase; HR, Height of rostrum. ——— *bactrianus*; — — — *musculus*; —·—·—·— F_1; x x x x back-cross.

Figure 1 also suggests the existence of growth gradients in the mature mouse skull. The mean values of k for the four classes increase in the following order: breadth, height, interorbital width, width outside molars, zygomatic width, rostral height and cranial capacity. The linear measurements fall naturally into two groups, horizontal and vertical. The first group includes breadth, interorbital width, width outside molars and zygomatic width, while height (of braincase) and height of rostrum are in the second. In the horizontal group, interorbital width, width outside molars and zygomatic width are anterior to breadth. In the vertical group, height of rostrum is anterior to height of braincase.

In the horizontal group, the anterior dimensions of each class have a higher growth coefficient than the posterior (breadth) with but one exception, the interorbital breadth in *bactrianus*. The vertical pair shows without exception that the anterior dimension (rostral height) has a higher coefficient than the posterior (height of braincase) of the same class. Figures 2 and 3 depict the situation graphically. It appears that even in skulls of mature mice the anterior portion is increasing relatively more rapidly than the posterior. This tendency of the anterior portion to be relatively more developed in the longer skulls recalls Klatt's ('13) observations on dogs and rabbits of large and small races.

SUMMARY

A study of differential growth in the skulls of mature mice of two species and their F_1 and back-cross hybrids has disclosed some facts of interest in the field of relative growth.

In general, a negative correlation exists between absolute skull length and the relative dimensions; breadth, height, interorbital width, zygomatic width, and width outside molars. Relative rostral height shows but slight correlation, mostly positive, with skull length, while relative cranial capacity displays a consistent positive correlation with the same absolute dimension. The relatively more narrow interorbital region and lesser rostral height of *Mus bactrianus* as contrasted with *Mus musculus* seem to be specific characters and not functions of absolute size. The lesser relative cranial capacity of the smaller species, on the other hand, may in part be the result of lesser absolute skull size.

The simple heterogony formula, $y = bx^k$, appears to describe fairly satisfactorily the increase in the several cranial dimensions in relation to skull length. Breadth, height, interorbital width, width outside molars, and zygomatic width are mostly negatively heterogonic, height of rostrum nearly isogonic, while cranial capacity is positively heterogonic.

In six of the seven dimensions, the growth coefficient of the F_1 hybrids is higher than those of the other three classes of mice. This may well be another manifestation of heterosis.

The existence of a growth gradient is indicated in the skulls of mature mice in that the anterior dimensions appear to increase more rapidly in relation to length than the posterior.

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NOTES ON THE JUMPING MOUSE ZAPUS TRINOTATUS TRINOTATUS RHOADS

BY ARTHUR SVIHLA AND RUTH DOWELL SVIHLA

Compared with the majority of small rodents, the jumping mice have had little published on their life history. Preble (1899) in his revision of the genus has given a general account of habits. Seton (1909) went into some detail on the same subject. Snyder (1924) recorded the activities of adults and gave information about the young of the northern woodland jumping mouse, *Napaeozapus insignis abietorum*, in Ontario. The following notes on *Zapus trinotatus trinotatus* were made while we were collecting mammals in the Olympic Peninsula and the Cascade Mountains of Washington, during the summers of 1931 and 1932.

In the Olympic Peninsula, jumping mice were found equally abundant in the dense forests bordering the Straits of Juan de Fuca at Bowman's Creek and the mouth of the Sekiu River, and in the alpine meadows near timberline at Boulder Lake. Along the Elwha River, some twelve miles inland, these mice were taken in the wet, open grassy areas as well as in the forests. At the Olympic Hot Springs, about half-way to timberline, twelve jumping mice were caught in a small marshy place

where the western skunk cabbage grew abundantly. While camping near timberline at Boulder Lake, we set live traps in the tall meadow grass and low blueberry bushes near the lake. One trap was baited with a fresh fish head. At dusk this trap was heard to snap and investigation disclosed a jumping mouse captured in it. The trap was reset, and within half an hour six more jumping mice were caught in the same place.

All the habitats in which *Zapus* were collected were wet marshy places. Preble (1899, p. 8) mentioned the fact that these mice show a "marked preference for moist locations." Although jumping mice seemed nowhere to be as common as deer mice or meadow mice over any sizeable area, they were abundant in local marshy places.

During this past summer (1932) a collecting station was maintained at Lake Kachess, which is located on the east slope of the Cascade Mountains. In the marshy underbrush along the edge of the lake a number of freshly-used runways of the mountain beaver (*Aplodontia*) indicated a colony of these animals. Several jumping mice were caught here in the runways, which at times were filled with water. One morning (July 11, 1932) a spring-floor trap set in one of these runways was found to contain a female jumping mouse and six newly born young. The trap was quite wet, as it had rained during the night, but the young, though cold, were still alive. They were slightly smaller in size than newly born harvest mice (*Reithrodontomys megalotis megalotis*; R. D. Svihla, 1931, p. 365) and weighed .7, .8, .8, .8, .9, and .9 gram. They were pink in color and hairless, with not even the vibrissae visible, differing in this respect from the newly born young of any other North American rodent yet described. Their eyes were closed, their ears were still folded and their heads were short and stubby. The tails were noticeably longer than those of newly born deer mice (*Peromyscus*). The bodies were surprisingly small when compared with the newly born deer mice of the *Peromyscus maniculatus* group (A. Svihla, 1932, p. 26), the adults of which are about the same size and weight as the adult *Zapus*, while the young *Peromyscus* average at birth 1.72 grams in weight. The jumping mouse was very nervous and abandoned her young, which were later preserved as specimens. Snyder (1924, p. 236) described finding five young *Napaeozapus insignis abietorum* in a nest during the last of June. They were naked and blind, and he judged them to be a week old.

Several pairs of jumping mice were brought back to the laboratory after the summer's collecting in 1931 for further observation on their

life habits. They did not prove to be very satisfactory laboratory animals, because of their high-strung nervous dispositions which made observations difficult.

On several occasions these rodents were seen to make a drumming noise by rapidly vibrating their tails against some resonant body such as the bottom of a tin can trap or shreds of paper used for nesting purposes. They also make a squeaking noise when fighting.

As has already been observed (Preble, 1899, p. 8; Seton, 1909, p. 596), the long tail of this mouse serves admirably as a balancing organ. The following incident is added to those already mentioned by the above authors. A mouse caught in a rat trap last summer had its tail broken off near the base but was otherwise uninjured. When released from the trap, it made several desperate leaps to escape. These jumps were about a foot high and for a distance of three feet. It could not land on its feet properly, but instead turned somersaults and landed on its back every time. With the loss of its tail there was no compensation made for the vigorous push of the long hind legs.

During September and October the mice gained perceptibly in weight until they were extremely fat. As their weight increased, they became more and more listless and drowsy, often spending days curled up in their characteristic hibernating position, bent over so that the head is between the hind legs and the long tail curled completely over the head and body. When taken in the hand or into a warm room they uncurled and began to move about slowly. When the temperature rose in the room, they became active and even ate solid food; but when the temperature dropped again they went back into hibernation. We think that this food remained undigested and caused their death, for during the winter they all died.

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A NEW HETEROMYID RODENT FROM THE OLIGOCENE OF MONTANA

BY ALBERT ELMER WOOD

Four fossil mammals were collected by Douglass in the Sage Creek region of southwest Montana, about seven miles north of Lima, Beaverhead County, in 1897. Douglass (1903) identified them as *Heptodon*, *Hyrachyus*, and ?*Metamynodon*, which would indicate that the Sage Creek Beds extended from Lower Eocene to Middle Oligocene. Matthew (1909) suggested, as more probable, ?*Helaletes*, *Hyrachyus* and ?*Amynodon*, reducing the range of the fauna to the Middle and Upper Eocene. Similar determinations have recently been made by H. E. Wood (in press).

A party, consisting of A. E., F. D., and H. E. Wood, and Rolena Dowden, spent three days (August 23–25, 1931) in this area, attempting to secure fossils that might solve the problem of the age of these beds. It was thought that they might turn out to be of an age intermediate between the Uinta and the Chadron, equivalent to the Duchesne Formation of Utah, recently described by Peterson, and the similar horizon in the Sespe Formation of California, discovered by Stock. An area was found which fitted Douglass's description of one of the two localities where he found fossils, but no identifiable material was obtained. At another point in the same general area (within the big bend of Sage Creek), a small collection of Middle Oligocene fossils was made, which have been determined as follows (rodents and lagomorphs by A. E. Wood, others by H. E. Wood):

Leptomeryx evansi, left ramus of mandible with P_4–M_2 and fragments of other teeth.
Hyracodon sp., fragment of ectoloph of an upper cheek tooth.
Peratherium sp., right lower molar.
Palaeolagus haydeni, parts of lower jaws, and numerous upper and lower teeth.
Sciuromorph, P^3?
Heliscomys gregoryi, n. sp., right maxilla with P^4–M^2.
Eumys, undescribed species, five lower jaws.
Turtle, fragments.

These fossils were found in a butte, immediately west of the road, opposite (west of) the front entrance to the buildings of the Cook Sheep Company Home Ranch, 8.1 miles by road north and east of the Dell railroad station, in Township 12 South, Range 33 East, Sections 27 and 34. This butte forms the west (right) wall of the valley of Sage Creek, in that part of its course which flows south. The fossils were found in three small pockets, at essentially the same stratigraphic level, being either just above, or just below, a prominent sandstone lens. As these beds are definitely of a different age from those described by Douglass as the Sage Creek Beds, a new formation name is required, and Cook Ranch is elsewhere proposed (H. E. Wood, in press; this locality is marked "1" on his map, fig. 51). The Cook Ranch resembles the Brule of the Big Badlands in composition and erosion forms. Most of the exposure consists of a gray clay, though there are intercalated sandstones, a foot or less in thickness, resembling the *Metamynodon* sandstones. These exposures dip ten degrees, S 10° E. The thickness of the beds here exposed was estimated as 125 feet. At the top of the bluff is a coarse gravel, of undetermined age, lying horizontally and unconformably above the Cook Ranch Beds. Similar gravels are found at a considerably lower altitude a short distance to the north.

On the basis of the additional characters shown by the maxilla found in this locality, the genus *Heliscomys* may be re-defined as follows:

Heliscomys Cope, 1873

The cheek teeth are tubercular, with a cingulum (internal in the upper jaw, external in the lower jaw) which develops into a pair of cusps on M^{1-2}_{1-2}. This is the earliest known and most primitive heteromyid, the cusps not yet having begun to unite into lophs, although they are aligned into two transverse rows. In this, it differs from all known later forms, to which it is, at least, morphologically ancestral, since it has the fundamental ground pattern for the cheek teeth of all the later members of the family. It is known from the Middle Oligocene of Colorado and Montana.

Heliscomys gregoryi, new species

(Fig. 5)

Type. — Maxilla with P^4–M^3 right, No. AW100, personal collection of A. E. Wood.

Horizon and *Locality.*—Type locality of the Cook Ranch Oligocene, butte west of Sage Creek, opposite Cook Ranch, 8 miles north and east of Dell, Beaverhead County, Montana. Collected by A. E. Wood, August 24, 1931, from near the bottom of the exposures, in pocket no. 2.

Diagnosis.—P^4 has a single anterior cusp and a posterior row of three cusps. M^{1-2} are sextitubercular with the internal cingulum cusps equal in height to the protocone and hypocone. M^3 bears a strong internal cingulum which, unlike the internal cingula of the other two molars, has not yet divided. The only other known species of the genus, *H. vetus*, from the Middle Oligocene of Colorado, is represented only by the lower jaw, which renders direct comparison difficult. *H. gregoryi* seems, however, to represent a distinctly more progressive evolutionary stage, in that the cingulum cusps of M^{1-2} have attained an elevation equal to that of the protocone and hypocone. It is thus intermediate in character between *H. vetus* of the Cedar Creek Brule on the one hand, and *Mookomys parvus*, perhaps of the Lower Miocene, and *Proheteromys floridanus* of the Middle Miocene, on the other. It is certainly not referable to any one of these forms. The fact that *H. gregoryi* is known only from upper teeth, and *H. vetus* only from lowers, makes it impossible to separate the discussion of generic and specific characters.

DISCUSSION

The fundamental plan of P^4 of *Heliscomys gregoryi* is already essentially the same as that of *Perognathus*, though the tooth is more primitive in that it has not yet begun to become either hypsodont or lophodont. There is a single anterior cusp, followed by a curved row of three posterior cusps. The anterior cusp has, on its antero-external border, a small cuspule, forming the most anterior point of the tooth, which seems to be a much-reduced paracone. The larger anterior cusp would then be the protocone. This stage definitely foreshadows the condition in *Perognathus* which has a single anterior cusp (fig. 3). *Proheteromys*, *Heteromys* and *Liomys*, on the other hand, have better developed paracones, which may indicate that they are descended from species of *Heliscomys* in which this cusp was not yet so greatly reduced. *Dipodomys*, however, has a more specialized P^4 than do the other forms, as it is formed by three lophs, and is probably developed from the perognathine type by the upgrowth of an anterior cingulum. In *Heliscomys*, the three cusps of the posterior row are a lateral metacone, a central hypocone, and a median entostyle. The arrangement in *Perognathus* differs only in that the antero-posterior valleys between the cusps have become greatly shallowed, and enter the main valley as "hanging valleys." The anterior face of P^4 of *H. gregoryi* slopes posteriorly from the alveolus to the crown, making the crown length noticeably shorter than the alveolar length, though nowhere nearly as much so as in the recent, more hypsodont genera (see table 1).

In M^1, the four primitive cusps are arranged as in *H. vetus* (fig. 7). The cingulum, which is well developed, entirely closing the median valley, is partially subdivided into a protostyle and an entostyle, which are of essentially the same height as the protocone and the hypocone. In all heteromyids, the two lophs, when worn, first unite on the side of the tooth originally bounded by the cingulum (i.e., on the inner side of the upper teeth and the outer side of the lower teeth), showing that this division of the cingulum has never become complete, even in the living genera (see Merriam, 1899, pl. 4, fig. 1, for a lateral view of the teeth of *Perognathus*), although this partial closure of the median valley is poorly defined in a crown view of an unworn tooth. The paracone and metacone are of about equal height, and are considerably higher than the other four cusps. The me-

dian valley opens unimpeded, buccally. Although the cusps have not yet united to form transverse lophs, they show incipient tendencies in that direction, as the antero-posterior valleys are slightly shallower than the median one. The styles do not form a straight line with the corresponding pair of primary cusps, but each style is slightly anterior to its associated cusps, thus foreshadowing the

TABLE 1

Table of measurements

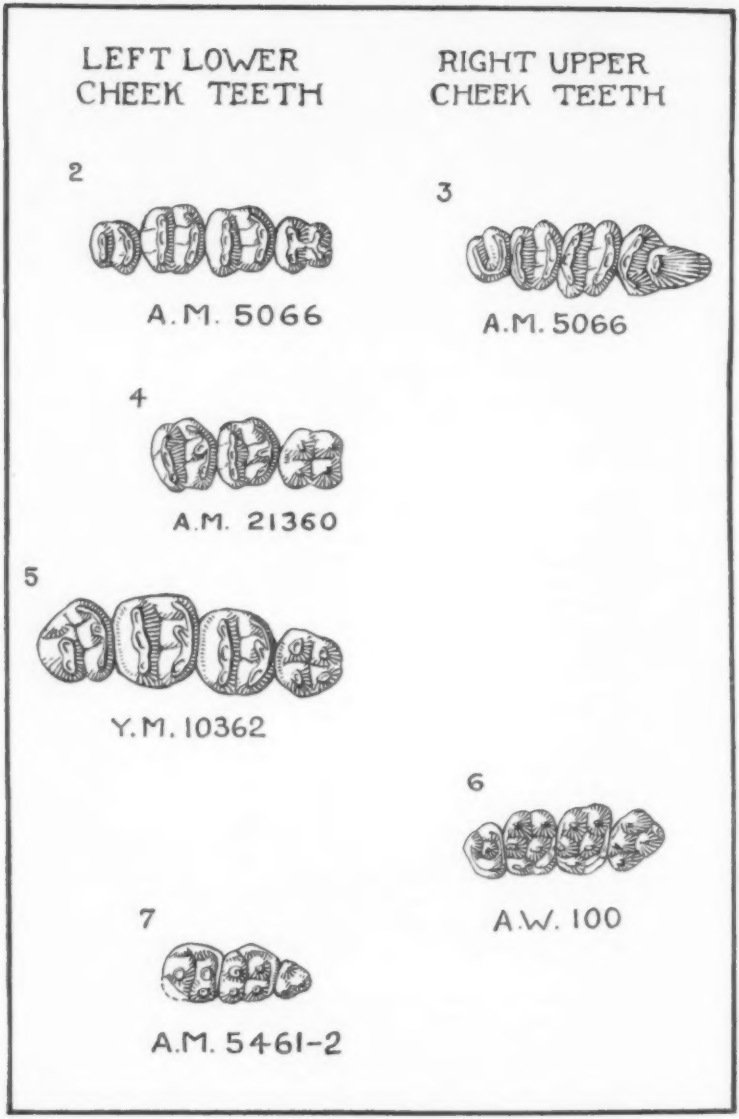
(All measurements in millimeters, by A. E. Wood)

	HELISCOMYS VETUS	HELISCOMYS GREGORYI	MOOKOMYS PARVUS	MOOKOMYS ALTIFLUMINIS	PEROGNATHUS FALLAX	
	A.M.N.H., No. 5461 and No. 5462	A.W., No. 100	Y.M., No. 10362	A.M.N.H., No. 21360	A.M.N.H., No. 5066	
	Left lower teeth	Right upper teeth	Right lower teeth	Left lower teeth	Right upper teeth	Left lower teeth
Length of tooth row		3.02	4.85		3.85[1]	3.55
Length of fourth premolar	0.48	0.85[2]	0.99	0.95	1.54[3]	0.90
Width of anterior loph, P 4	0.55	0.60	0.92	1.05	0.65	0.65
Width of posterior loph, P 4	0.55	1.00	1.02	0.80	1.22	0.90
Length of M 1	0.84	0.82	1.28	1.10	0.90	1.05
Width of anterior loph, M 1	0.83	1.08	1.32	1.15	1.25	1.05
Width of posterior loph, M 1	0.84	1.04	1.22	1.15	1.22	1.00
Length of M 2	0.82[4]	0.80	1.30	1.00	0.77	0.95
Width of anterior loph, M 2	0.82[4]	1.02	1.44	1.10	1.05	1.10
Width of posterior loph, M 2	0.83[4]	1.00	1.32	1.10	0.90	1.05
Length of M 3		0.55	1.20		0.73	0.80
Width of anterior loph, M 3		0.80	1.23		0.75	0.80
Width of posterior loph, M 3		0.60	1.03		0.70	0.70

[1] Length at alveolus. Crown length = 3.10.
[2] Length at alveolus. Crown length = 0.70.
[3] Length at alveolus. Crown length = 0.75.
[4] Measured from referred specimen, A. M. N. H. No. 5462.

curved lophs found in *Mookomys parvus* (Troxell) and later heteromyids (figs. 2–5; these figures are arranged in the form of a phylogenetic chart, showing several stages in the evolution of the upper and lower teeth). These incipient lophs are concave anteriorly, as in the upper teeth of later forms, and as opposed to those in the corresponding lower teeth, which are convex anteriorly. An anterior cingulum connects the paracone and the protostyle.

M^2 is very similar to M^1, and is but a shade smaller, suggesting that the proportionately smaller size of this tooth in *Perognathus* and *Dipodomys* is secondary, and that *Heteromys* is more primitive in this respect.



FIGS. 2–7. DENTAL EVOLUTION OF HETEROMYIDS

Left column, left lower cheek teeth; right column, right upper cheek teeth. All × 10. For further explanation, see bottom of next page.

M^3 is less specialized than either of the other molars. On the buccal side are the paracone and the metacone. In the center of the tooth is the protocone, rising from, and nearly filling, a central basin. This basin is rimmed by a cingulum, running from the paracone to the metacone, along the anterior, median, and posterior margins of the tooth. On the lingual side, median to the protocone, the cingulum is somewhat enlarged, to form a protostyle. Whether or not M^3 of *Perognathus* has been derived from M^3 of *Heliscomys gregoryi* by way of the stages represented in the other two molars, is at present impossible to determine.

The posterior end of the zygomatic root is opposite P^4, as in the living members of the family. Two posterior palatine foramina appear, as in the recent genera, the anterior one opposite the posterior end of M^1, and the posterior one median to M^3.

The comparisons of the teeth given so far have been more with the recent genera than with the more closely related fossil forms, as, unfortunately, these latter are known only from lower jaws, and hence no direct comparisons can be made. In the heteromyids, however, the first and second upper and lower molars, where known, usually approximate mirror images of each other. *A priori*, it would seem probable that the teeth would begin to resemble each other in this manner as soon as they had reached a quadritubercular plan, as in *Sciuravus nitidus* Marsh of the Bridger Eocene, and that thereafter the resemblance would remain or be accentuated, the two sets of teeth evolving together. As the molars not only of *Heliscomys gregoryi*, but also of *H. vetus*, have reached such a stage, tentative comparisons may be made between these, and between the upper teeth of *H. gregoryi* and the lower teeth of the later members of the family.

The difference in plan between P^4 of *H. gregoryi* and P_4 of *Mookomys parvus* is essentially the same as that between the upper and lower premolars of the modern *Perognathus*, though a vestige of the paracone is retained in *H. gregoryi*, which is absent in *Perognathus*. P_4 of *Proheteromys floridanus* Wood, on the other hand, from the Middle Miocene of Florida, is already specializing in another direction, tending toward the pattern found in *Heteromys*. The arrangement of the cusps in the first two molars of *Heliscomys gregoryi* has the essentials for a form ancestral to *Mookomys parvus* and to *Proheteromys floridanus*, in that the requisite number of cusps are present, arranged in two parallel rows. The most important difference is the shoaling of the antero-posterior valleys of the two latter species, whereby the six cusps are combined into two lophs. M^3 of *H. gregoryi* is considerably more primitive than is M_3 of *M. parvus*.

The advances of *H. gregoryi* over *H. vetus* lie in the further development of the cingulum, and the more progressive character of the premolar. As indicated by the table of measurements, the transverse dimensions of *H. gregoryi* show much

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Fig. 2. *Perognathus fallax*, Amer. Mus. Nat. Hist., no. 5066, P_4—M_3 left.

Fig. 3. *P. fallax*, Amer. Mus. Nat. Hist., no. 5066, P^4–M^3 right.

Fig. 4. *Mookomys altiſluminis*, Amer. Mus. Nat. Hist., no. 21360, P_4–M_2 left.

Fig. 5. *M. parvus*, Yale Mus., no. 10362, P_4–M_2 right, reversed.

Fig. 6. *Heliscomys gregoryi*, collection of A. E. Wood, no. AW100, P^4–M^2 right.

Fig. 7. *H. vetus*, Amer. Mus. Nat. Hist., nos. 5461, 5462, P_4–M_2 left.

more pronounced increases over those of *H. vetus* than do the antero-posterior dimensions. This largely reflects the widening of the cingulum, which has become markedly expanded in *H. gregoryi*.

H. gregoryi is closer in size to *Mookomys altifluminis* Wood (fig. 4) from the Deep River Miocene near Ft. Logan (not Logan, as stated in Wood, 1931), Montana, than to the larger *M. parvus* from the ?Lower Miocene of ?Colorado. But the more specialized pattern of the teeth of *M. altifluminis* indicates that it is descended from a form similar to *M. parvus*, and, as variations of size are of relatively minor significance, we are justified in considering these as forming an approximate morphological line.

Heliscomys gregoryi, then, is a heteromyid intermediate between *H. vetus* of the Cedar Creek Brule on the one hand, and *Mookomys parvus*, perhaps of the Lower Miocene of Colorado, and *Proheteromys floridanus* of the Middle Miocene of Florida, on the other. Its characters, as far as known, are what one would expect to find in such a stage. The advance in specialization of *H. gregoryi* over *H. vetus* may indicate that it occurs at a slightly higher horizon, or merely show that, at a given period, a species living in one locality may be more progressive than one living in another. The fauna associated with *H. gregoryi* seems to be all of a typical Middle Oligocene type (though a mountain valley fauna rather than a plains fauna, as is indicated by the apparent absence of such forms as oreodonts and horses, in addition to geographic considerations), showing that the Cook Ranch Beds are not later than upper Middle Oligocene. As Douglass's fossils are certainly Eocene, this area is apparently one of the few known in this country where continental Eocene beds are overlain by continental Oligocene, and would doubtless repay more intensive stratigraphic study.

All fossil heteromyids that have been reported are from the United States, as opposed to the living species, which center in the southern United States and northern Mexico, extending as far south as Venezuela, Colombia, and northern Ecuador (*Heteromys*) while *Perognathus* extends into British Columbia. The known distribution of the fossil forms is due in part, at least, to the much more intensive and extensive collecting that has been done in the United States, but the presence of Oligocene heteromyids in Montana and Colorado, together with the known paleogeographic conditions, suggests that the evolution of the family may have taken place largely within the United States, and that the southern forms moved into their present habitats during the later Tertiary, and have only reached South America since the elevation of the Panama land bridge at the end of the Miocene or the beginning of the Pliocene. Two new species of heteromyids (*Proheteromys floridanus* and *P. magnus*), whose dental structure is intermediate between *Heliscomys* and *Heteromys*, have recently been described (A. E. Wood, 1932) from the Middle Miocene of Florida, thus considerably extending the known geographic range of the family, since this is the first reported occurrence east of the Mississippi.

I wish to express my appreciation to Dr. Florence Dowden Wood, who very kindly made the drawings and photographs with which this paper is illustrated. I am also indebted to Professors W. K. Gregory and H. E. Wood for critical readings of the manuscript, together with numerous suggestions. This study has been aided by a grant from the Marsh Fund of the National Academy of Sciences.

SUMMARY

Heliscomys gregoryi, new species, from the Cook Ranch Middle Oligocene of Beaverhead County, Montana, is intermediate in dental characters between *H. vetus*, from the White River of Colorado, on the one hand, and *Mookomys parvus*, perhaps from the Lower Miocene, perhaps of Colorado, and *Proheteromys floridanus* from the Middle Miocene of Florida, on the other, and helps to fill one of the principal gaps in the dental evolution of this family of rodents.

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A NEW SHREW FROM THE UPPER PLIOCENE OF IDAHO

By C. Lewis Gazin

Included in the fossil material collected during 1929, 1930 and 1931 by Mr. Elmer Cook of Hagerman, Idaho for the U. S. National Museum is a portion of a mandible belonging to a shrew. This specimen and other remains of a varied fauna including horse, camel, sloth, carnivores, rodents, turtles, birds and fish were encountered in late Pliocene lake beds exposed along the west side of the Snake River in Twin Falls County, Idaho, near the town of Hagerman.

The general collections made by Mr. Cook have been of great value in supplementing the remarkable Smithsonian collection made during the summers of the same years at the *Plesippus* Quarry[1] by Dr. J. W. Gidley and Mr. N. H. Boss.

Blarina gidleyi, new species

Type.—A fragmentary left ramus of the mandible, No. 12650 U. S. N. M., with the three molar teeth.

Locality.—T. 7 S., R. 13 E., near Hagerman, Idaho.

Horizon.—Hagerman lake beds, Upper Pliocene.

Specific characters.—Size near that of *Blarina brevicauda*. Mental foramen farther forward. Inferior margin of ramus less angulate below posterior portion of M_3. Trigonid of lower molars elongate antero-posteriorly with more obtuse crest. Posterior wall not so nearly perpendicular to lingual margin of tooth. Talonid narrower and crest of talonid joins posterior wall of trigonid at a more inward position. Cingulum more outstanding at postero-external margin of first two molars.

Description.—The fossil form corresponds closer in size and general proportions to species of *Blarina* than to any of the other North American shrews. However, in comparison with a large number of specimens of *Blarina brevicauda* several differences were observed which appear to separate the fossil from the modern form. The mental foramen is slightly farther forward, but is not so anteriorly placed as in *Sorex*, and the angulation of the inferior border of the ramus is not so sharp as common in *Blarina brevicauda*. A less angulate inferior profile was noted by Mr. Barnum Brown[2] in his description of *Blarina brevicauda ozarkensis* from the Pleistocene of Arkansas. In the lower molars Brown's subspecies resembles *B. brevicauda* more closely than *B. gidleyi*.

The lower molars of the Idaho specimen though corresponding in size and general robust condition to these teeth in *Blarina brevicauda* show differences which appear to be beyond the range of variation seen in both *Blarina brevicauda* and

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[1] See J. W. Gidley, Journ. Mammalogy, vol. 11, No. 3, pp. 300–303, 1930, and C. W. Gilmore, Proc. U. S. Nat. Mus., vol. 82, pp. 1–7, 1933.

[2] Barnum Brown, Mem. Amer. Mus. Nat. Hist., vol. 9, pp. 170–171, 1908.

Blarina telmalestes. The trigonid portion of these teeth is elongate giving the crescentic crest a more obtuse appearance than in the living species and the posterior portion of this crest is not so nearly perpendicular to the inner margin of

FIG. 1. BLARINA GIDLEYI, new species

Left ramus of mandible with molar teeth, No. 12650 U. S. N. M., lateral and occlusal views; x 3.0. Hagerman lake beds, Upper Pliocene, Idaho. Drawing by Mr. Sidney Prentice.

TABLE 1

Measurements in millimeters

	B. GIDLEYI No. 12650 U.S.N.M.	B. BREVICAUDA No. 83073 U.S.N.M.
Total length of lower molars, M_1–M_3	5.0	5.0
M_1, anteroposterior diameter along inner margin	2.0	2.0
M_1, anteroposterior length of trigonid	1.4	1.2
M_1, transverse width of trigonid above external cingulum	1.1	1.1
M_1, transverse width of talonid above external cingulum	1.1	1.3
M_2, anteroposterior diameter along inner margin	1.7	1.7
M_2, anteroposterior length of trigonid	1.05	1.0
M_2, transverse width of trigonid above external cingulum	1.0	1.0
M_2, transverse width of talonid above external cingulum	0.9	1.2
M_3, anteroposterior diameter along inner surface	1.3	1.3
M_3, anteroposterior length of trigonid	0.8	0.75
M_3, transverse width of trigonid above external cingulum	0.6	0.7
M_3, transverse width of talonid above external cingulum	0.5	0.6

the tooth, being directed slightly forward externally. The talonid portion of the anterior molars is narrower transversely, and the crest meets the posterior wall of the trigonid at a more inward position somewhat as in *Sorex*. Also, the postero-external wall of the talonid crown in M_1 and M_2 does not project bucally

beyond the cingulum so noticeably as in *Blarina brevicauda*, consequently the cingulum appears better developed at this point.

A comparison of *Blarina gidleyi* with various genera of smaller North American shrews shows the fossil form to have teeth of larger size with stouter cusps though relatively less hypsodont. *Sorex* is relatively small with delicate hypsodont teeth. In the *Sorex cinereus* group the entoconulid in the first and second molars extends a high ridge toward the metaconid. This ridge is not so conspicuous in *Blarina*. Also, the heel of the third lower molar is usually well developed in *Sorex*. In the subgenera *Neosorex* and *Atophyrax* the lower molars resemble those of *Sorex* more closely than those of *Blarina*. The small short-tailed shrew *Notiosorex crawfordi* also has hypsodont lower molars, the first two of which are further characterized by having the talonid portion long and the trigonid short anteroposteriorly, somewhat as observed in specimens of *Crocidura*. *Notiosorex gigas*, however, is characterized by specimens of remarkable size with more brachydont teeth, comparable in these respects to *Blarina*. Although the crest of the talonid meets the trigonid at a more inward position as in *Blarina gidleyi*, the relatively long heel and short trigonid in specimens examined separates it from *B. gidleyi*. In *Cryptotis*, particularly the more northern species, the talonids of the lower molars are anteroposteriorly short, that of M_3 being noticeably reduced. This is not so clearly shown in some specimens of Mexican species of *Cryptotis* examined.

The reduction of the heel of the last lower molar which is often so marked in *Cryptotis* is a character which distinguishes *Blarina simplicidens* Cope[3] in the Pleistocene of Pennsylvania from the living species of *Blarina* and from *Blarina gidleyi*.

Remarks.—The occurrence of *Blarina gidleyi* extends the known record of this genus into late Pliocene time. Previously *Blarina* was not known in deposits older than Pleistocene. Furthermore, its occurrence in Idaho is outside the present geographic range of this group of shrews. *Blarina brevicauda* is distributed through eastern United States, occurring in the Central Lowland province or Prairie region, but its range does not extend westward across the Great Plains and Rocky Mountains into the Intermontane Plateau region.

It is possible that were more complete remains known the fossil form would be found to represent an undescribed genus, presumably related closely to *Blarina*.

U. S. National Museum, Washington, D. C.

[3] E. D. Cope, Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 11, p. 219, 1899.

THE TRAMMEL NET AS A MEANS OF COLLECTING BATS

By Josselyn Van Tyne

A long-cherished ambition to try out Italian bird netting methods in a tropical jungle was realized in 1931 when, on the eve of my departture for Guatemala, my friend, Oliver L. Austin, Jr., loaned me an imported linen bird net.

The net was about 40 feet long and over 6 feet high. The two coarse outer nets were made up of squares about 7 inches on a side, while the central net, which was of much finer texture than the finest fish net, had a three-quarter inch mesh. The whole was suspended by little metal rings from a stout cord.

Early in April, soon after my arrival at the Carnegie Institution's archaeological base at Uaxactun, Guatemala, I picked out a convenient but secluded spot in the big forest nearby and set out the net. It not only began immediately to catch the expected birds, but one morning, to my great surprise, I found a bat tangled in it. Knowing of the great skill shown by flying bats in avoiding obstacles, I considered this somewhat of a miracle. But the next morning there were *eight* squeaking bats struggling in the net when I arrived, and the following morning there were *nine*, and so it went. My companion, Adolph Murie, mammalogist of the expedition, has since identified the bats we netted there and kindly provided me with the following list of the total catch:

Glossophaga soricina leachii, 1 on May 2.

Carollia subrufa, 1 on May 2; 1 on May 11.

Artibeus jamaicensis yucatanicus, 8 on April 17.

Artibeus nanus, 1 on April 14; 8 on April 15; 9 on April 16; 8 on April 17; 2 on April 23; 1 on May 1; 2 on May 2; 1 on May 4; 1 on May 5; 1 on May 10; 4 on May 11; 1 on May 12; 3 on May 13; 1 on May 14.

Desmodus rotundus murinus, 1 on May 2.

The net was set at the first location, in the open undergrowth of the big forest, from April 7 to 25, and then was moved to a dense thicket at the very edge of the jungle and was maintained there from April 30 to May 14.

To set such a net it is best to select two trees the right distance apart and then clear *completely* a "right of way" between them, leaving the ground bare. If this is not done thoroughly, much time will be wasted later in disengaging twigs and leaves from the net. Then stretch the suspending rope tightly between the trees about 7 feet high and spread

the net to its full extent. One upper corner of the net is tied permanently to the rope and the free end may be held in place conveniently with a clothes-pin. Then place hooked stakes in the ground every few feet and stretch the trammels down and hook them on the stakes. It is important that the outer trammels should be taut. The fine inner mesh should then be pulled up between the trammels so that it hangs evenly and loosely all over the net and any bird or bat striking it will make a pocket and become entangled instantly.

Frequently the bats were caught in the very bottom of the net as though they had been skimming low over the ground. There was also a distinct tendency for bats to be found in groups in the net, as though several had been caught while fluttering about the first one caught. The longer birds or bats remained in the net the more difficult it was to remove them. Birds could always be removed unhurt, but bats often got so much of the net in their teeth that it was virtually impossible to remove them alive. The bats' sharp teeth played havoc with the net, whereas small birds rarely did appreciable damage. My experience with a small Chinese silk net that I used at the same time showed that bats and large beetles are very much more destructive to silk nets than to linen ones.

The fact that none of the 5 species of bats above listed were otherwise included in the 33 species of mammals collected by Mr. Murie at Uaxactun, indicates the value of this method of collecting. For use in regions where there are no caves or old buildings to harbor bats, or for securing forest bats that do not roost in caves, this new method may well prove, when fully developed and tested, to be a really important addition to our collecting technique.

University Museums, University of Michigan, Ann Arbor, Michigan.

LONGEVITY IN PEROMYSCUS MANICULATUS GRACILIS

By Lee R. Dice

Some records of the length of life of *Peromyscus maniculatus gracilis* (Le Conte) indicate that this subspecies has a longer life span than *P. m. gambelii*, another geographic race of the same species, which has been studied by Sumner.[1]

My stock of *gracilis*, eight mice in all, was secured near Elmira, Otsego County, Michigan, in September, 1923. All of the original animals, except two that escaped, were prepared as specimens when they had been in captivity more than 3 years. A few of the offspring died in early life from unknown causes, but most were killed and prepared as specimens. Only a few individuals were kept until they died of old age. Of those which died at ages over 2 years, two females reached ages, respectively, of 3 years, 2 months, and 5 years, 3½ months. Three males reached ages of 5 years, 7½ months, 7 years, and 8 years, 4 months, respectively.

The female that died at 3 years, 2 months could hardly have died of old age, for a number of the females which were killed for specimens had reached greater ages. Two of the females caught in the field had been in captivity 3 years, 10 months, when killed. Two cage-born females when killed were, respectively, 4 years, and 3 years, 4 months of age.

Many of the oldest animals showed evidence of senility. In the old mice in general there was a stiffness in movements and a lack of vigor; the body was lean, sometimes almost emaciated; the pelage seemed to be thin; and the color was paler than normal for animals in their prime, but was never entirely white.

Nearly all races of *Peromyscus* seem to be most fertile in their first year, but *gracilis* in my laboratory seems to be a little slow in starting to breed. My stock of *gracilis* had become quite infertile before this was noted, and perhaps its relative infertility is the reason for the late production of litters. Most of the matings producing offspring were made after the animals were over a year old, so the evidence is not at all conclusive that they would not breed at younger ages. Two matings of 10-months' old males and females resulted in litters when the parents were aged 1 year, 5 months, and 1 year, 9 months, respectively.

The reproductive period in *gracilis* seems to be prolonged to a relatively old age. Some of the pairs continued to be productive until they were

[1] F. B. Sumner, Journ. Mamm., vol. 3, pp. 79–81, 1922.

3 years or more old. One pair of wild-caught mice had a litter when they had been in captivity 3 years and 1 month. Shortly after this they were prepared as specimens, and there is no evidence that they had at that time become infertile. In the oldest fertile pair of *gracilis* of which I have record the female was 4 years 3 months old and the male 5 years 10 months old at the time of the birth of their last litter. Another male was 5 years, ½ month old at the time of the birth of his last litter.

The age at death of the oldest male *Peromyscus maniculatus gambelii* recorded by Sumner was 4 years, 5 months, and of the oldest female 5 years, 8 months. The oldest fertile mice of this subspecies were more than 34 months old at the birth of the last litter, or a little over 2 years, 10 months.

It will be noted that the oldest female *gambelii* attained an age several months greater than the oldest female *gracilis*. However, the oldest male *gracilis* lived to be nearly twice as old as the oldest male *gambelii*, and two other male *gracilis* lived to be rather old. The numbers are too few for reliable conclusions to be drawn as to whether males or females of these mice live the longer.

Perhaps the apparently greater length of life and longer period of fertility in *Peromyscus maniculatus gracilis* as compared to the related subspecies *gambelii* is due in part to differences in the laboratory environments. The *gracilis* mice were kept at Ann Arbor, Michigan, in laboratories heated in winter, while the *gambelii* were kept at La Jolla, California, in a laboratory without artificial heat. The food also of the two stocks was different. However, it is my opinion that the differences described can hardly be due to environment alone. The evidence, although scanty, indicates that the northern race, *gracilis*, is genetically somewhat longer-lived than its more southern relative *gambelii*.

University of Michigan, Ann Arbor, Michigan.

TWO NEW BATS FROM AUSTRALIA

By Glover M. Allen

In the summer of 1932 a party of six, representing the Museum of Comparative Zoölogy, visited Australia under the leadership of Professor William M. Wheeler, for the purpose of studying its fauna. Much of the time was spent in the southwestern part of the continent, which proved to be poor in mammalian life; but later, Dr. Philip J. Darlington of our number made collections in northern Queensland, after the return of four of the party. To his keenness and skill as a collector is due a fine series of skins from this tropical rain-forest region. He made an especial effort to collect bats and was successful in obtaining a number of interesting species, including the two new forms here described. In partial acknowledgment of the abundant kindnesses shown our party by the many Australian naturalists whom it was our privilege to meet, the paratypes of these are to be presented to the Queensland Museum, at Brisbane.

Rhinolophus megaphyllus ignifer, new subspecies

Type.—An adult male, skin and skull, No. 29078 (paratype, No. 29079) Museum of Comparative Zoölogy, from Coen, Cape York, Queensland, Australia; collected June 12, 1932, by Dr. Philip J. Darlington.

Description.—Differs from the typical race of New South Wales in that (1) the adults have a bright rufous phase, while (2) in the gray phase the hairs are darker at the base than in the terminal portion, whereas in the other the hair is practically of the same tint throughout its length.

In the rufous phase (represented by the type and paratype) the entire pelage above and below is a uniform bright "ferruginous" (Ridgway), except that the glossy tips of the hairs give a somewhat golden shimmer in some lights; on the lower surface this golden appearance is more marked across the abdominal area. In the gray phase, the northern bat has the basal part of the fur on the dorsal side a dark "seal brown," the hairs minutely tipped with pale gray, so that on close inspection the fur is darker basally than at the surface of the coat. The same condition is true of the ventral surface, where the pale tips are more extensive and even more strikingly contrasted with the darker bases of the hairs. In the typical race the dorsal pelage is paler, without the contrasted tips, and on the ventral surface is a nearly uniform "Prout's brown," quite different from the dark-based and pale-tipped fur of the northern race.

Measurements.—The type and paratype measured respectively: total length, 77, 76 mm.; tail, 22, 23; hind foot, 9, 9; ear, 20, 20. The forearms are 46 and 45.5 mm. The skulls measure respectively: greatest length, 20.7, 20.4 mm.; basal length, 17.0, 16.7; palatal length, 6.6, 6.5; zygomatic width, 9.6, 9.9; width across molars, 6.9, 7.0; mastoid width, 9.4, 9.3; upper tooth row, canine to last molar, 7.5, 7.5; lower tooth row, canine to last molar, 8.0, 8.0.

Skull.—The skull of the northern race is not distinguishable from that of the southern. In both, the minute anterior premolar of the upper series stands practically in the tooth row between the base of the canine and that of the large posterior premolar. In the lower jaw, the corresponding tooth is more minute and tends to be forced outward from the line of the tooth row, with, however, a certain amount of variation, so that in some specimens the two large premolars practically touch behind it, while in others, these larger teeth are distinctly separate and thus the minute premolar is pushed less to the outer side.

Remarks.—The type locality of *R. megaphyllus megaphyllus* fortunately is near the southern part of the species' range, namely, the Murrumbidgee River, in southern New South Wales. Apparently the rufous phase is not known in this southern race, while its nearly uniform gray coloring, quite to the bases of the fur is in rather striking contrast to that of the more northern race here described, in which the gray phase is easily distinguished by its darker-based pelage with much grayer tips, both above and (especially) below. Typical *megaphyllus* ranges northward in the eastern part of Australia to northern New South Wales, whence Mr. A. J. Marshall, of Sydney, and I secured a good series from caves near Sherwood, west of Kempsey, and Dr. Darlington took a single one slightly farther north at Dorrigo. Doubtless the race *ignifer* is characteristic of the warmer and more saturate rain-forest area within the tropics, but the only specimens examined are those in the series secured by Dr. Darlington at Coen, Cape York, where there was a colony in an old mine tunnel. A few skins of this series show a slightly intermediate condition of pelage color, between the bright ferruginous and the gray phases. Curiously, this genus has not as yet been reported from Papua, but should it eventually be found there, its representative will probably be very like the Queensland race.

Eptesicus darlingtoni, new species

Type.—An adult female, skin and skull, No. 29113 (paratype, No. 29120) Museum of Comparative Zoölogy, from Macpherson Ranges, 3000 feet, Queensland National Park, Australia; collected March 10, 1932, by Dr. Philip J. Darlington.

Description.—General color above a bright dark brown, practically "seal brown" of Ridgway, with a slightly russet appearance in certain lights, due to the polish of the hair tips. Lower surfaces somewhat lighter, about "Prout's brown," without any strongly marked line of separation. The bases of the hairs above and below are slaty. On the dorsal surface of the uropatagium the fur extends thickly to near the level of the ankle. Ears of the usual shape in the genus, thin; the tragus rather elongate, parallel-sided in the dried specimens, with abruptly beveled tip, its width about one third the height.

The skull is a larger replica of that of *E. pumilus*, delicately formed, but with the rostrum relatively shorter, the distance from tip of incisor to the point of least interorbital width about two-thirds the remaining length of the skull instead of more than seven-tenths. The concavity on each side of the rostrum is well developed, and the antorbital foramen in both species lies over the front of the first molar. The inner upper incisor is large and bicuspidate; the outer incisor is much smaller, with a distinct cingulum and a single cusp, which is nearly half the height of the outer cusp of the first incisor.

Measurements.—The measurements of the type and paratype in order are: total length, 80, 79 mm.; tail, 34, 34; hind foot, 8, 8; ear, 10, 10; forearm, 35.7, 36.8. Skulls: greatest length, 13.6, 13.2; basal length, 11.1, 10.9; palatal length, 6.1, 5.9; zygomatic width, 8.6, 8.5; mastoid width, 7.8, 7.7; width outside molars, 6, 5.6; upper tooth row, 5.5, 5.4; lower tooth row, 5.9, 6.0. (Corresponding measurements of the skin of *E. pumilus caurinus*, from Millaa Millaa, Queensland, are: total length, 73; tail, 31; foot, 7; ear, 10; forearm, 30.5. Skull: greatest length, 12.0; basal length, 10.4; palatal length, 5.7; zygomatic width, 7.6; mastoid width, 6.5; width outside molars, 5.3; upper tooth row, 5.1; lower tooth row, 5.5).

Remarks.—Although much alike in structure and in color, the two species, *E. pumilus* and *E. darlingtoni*, are easily distinguished by size, the larger *darlingtoni* having a much larger skull, and a forearm some 5 mm. or more longer, differences which in such small bats are proportionally large and strikingly evident to the eye. The color of *darlingtoni*, both above and below, is a decidedly more russet tint of brown. The two offer another example of the phenomenon so often seen among bats, where two closely related species, differing chiefly in size, inhabit the same general area. It is a pleasure to associate Dr. Darlington's name with this interesting species, the discovery of which is one of the many important results of his skill as a collector.

Museum of Comparative Zoölogy, Harvard College, Cambridge, Mass.

GENERAL NOTES

THE NORTHWARD SPREAD OF THE OPOSSUM IN NEW YORK

In his "Lives of Game Animals" (vol. 4, no. 2, p. 897), Seton has pictured a map of the United States populated with opossums. In his studies on the range of this animal, he has shown how the opossum is marching northward with the years, and becoming firmly rooted as a citizen of the colder latitudes.

In my studies on the fur-bearers of New York State, I have had exceptional opportunity to see and handle both trappers' and buyers' lots, and have noted with pleasure the increasing abundance of opossum pelts in these collections.

While the opossum has been established in the New York City region and lower Hudson Valley for more than half a century, it is relatively recently that its advent in western New York has been marked. The following records, chiefly from the counties of the state collectively known as the southern tier, may prove of interest to students of distribution.

Chautauqua Co.: Mr. A. E. Beckman at Westfield informs me that the opossum is not uncommon in this region. Hunters account for a number each year.

Cattaraugus Co.: Mr. R. J. Feltham, a fur-buyer of Olean, writes me: "In the last few years we are getting quite a few opossums that are killed right in this section. We have had over thirty this season (1932-33) that were caught close to Olean. Ten years ago we never used to get any opossums."

Steuben Co.: Charles Crocker, a buyer at Kanona, purchased 20 opossums during the 1932-33 season. Formerly they were very scarce here.

Wyoming Co.: W. W. Kingsley, of Warsaw, bought two animals that were trapped near Perry, winter of 1932–33.

Schuyler Co.: Floyd Snyder, at Odessa, bought six opossums in 1932, two in 1931 and one in 1929. He had bought none previous to this.

Chemung Co.: Mr. R. L. Sloan, of the Elmira Hide and Tallow Company, bought nine opossums during the 1932 season that he knows were caught within the state.

Broome Co.: J. F. Talbot of Binghamton writes: "For quite a number of years we have bought a few opossums which we know have been caught in Broome County. It has been our observation that opossum skins taken in our vicinity are much heavier furred, with a longer and heavier guard hair, than skins taken in Ohio, Kentucky, and Tennesee. When the skins are fur-dressed, they look more like kit badger than like southern opossum. Probably a difference in climate."

Cortland Co.: Mr. Maurice Phillips of Ithaca, N. Y. saw a dead opossum on the highway at Cincinnatus, N.Y. on June 5, 1931.

Tioga Co.: Thomas Shelton of Owego bought a single animal in 1932. It was caught locally.

Orange Co.: James Ellis, a large dealer at Middletown, buys many opossums annually in his county. His belief is that they are becoming more numerous in the north because of the milder winter seasons.

Dutchess Co.: Probably they are not uncommon in the southern part of the county, but at Amenia Mr. John Molinaro, in seventeen years of trapping, has seen but two. It is of interest to note that each record is recent. In 1927 he trapped one, while another was observed dead on the highway during the summer of 1932.

Mr. C. E. Wilbur of King Ferry, Cayuga County, travels extensively throughout Genesee, Wyoming, Livingston, Ontario, Wayne, and other counties of the central and western portion of the state. While he specializes in northern furs, and does not buy from trappers in the southern counties, he collected 25 opossums during the winter of 1932–33.

Finally, the annual report of the New York State Conservation Commission gives a good criterion of the annual increase of this animal in the state. While these reports are not to be depended upon entirely, as many trappers do not file a report, we can yet see the rapid increase of the opossum in the past ten years. For 1920, 375 are listed; 1921, 597; 1922, 672; 1923, 573; 1926, 963; 1927, 1086; 1928, 1328; 1929, 1538.—W. J. Hamilton, Jr., *Cornell University, Ithaca, New York.*

OPOSSUM AND SKUNK EAT BATS

Examination of mammal stomach contents so seldom reveals the remains of bats that two recent cases seem worthy of record.

An opossum (*Didelphis virginiana*), Biological Survey no. 4723, collected January 8, 1930, by T. D. Burleigh in the Pisgah National Forest of North Carolina, had eaten a red bat (*Lasiurus borealis*). The bat was in several pieces but the entire body had been eaten and comprised 34 per cent of the total stomach contents. Other food items in the same stomach were: Hairy-tailed mole (*Parascalops breweri*), 42 per cent; insects (beetles, bugs, grasshoppers, and ants), 21 per cent; and millipeds, 3 per cent.

A skunk (*Mephitis elongata*), Biological Survey no. 4728, collected in the same locality on January 22, 1930, had eaten two silver-haired bats (*Lasionycteris noctivagans*). The remains were fragmentary although almost the entire bodies were present and made up 85 per cent the stomach contents. The remainder of the food was composed of insects (beetles, bugs, wasps, and caterpillars), 9 per cent, and centipedes, 6 per cent.—CHARLES C. SPERRY, *U. S. Biological Survey, Denver, Colorado.*

SOREX LEUCOGENYS IN ARIZONA

Individuals of the *Sorex merriami* group of shrews are so infrequently taken by mammal collectors as to justify application of the term "rare" to any of the three species of this group. On this account, and because an extension of known range is furnished, it seems desirable to record the taking, on July 15, 1932, by Miss Annie M. Alexander, of a nursing female of *Sorex leucogenys* Osgood at Sawmill Springs, 7300 feet altitude, eight miles southeast of Mormon lake, Coconino County, Arizona.

Miss Alexander's field notes record that the specimen, now no. 55181, Mus. Vert. Zool., was "taken at root of willow in thicket of rush grass, lupines, solomon-seal, violet, wild rose; three feet from water." The field notes, and accompanying photographs, show that the dominant types of trees here were yellow pine and quaking aspen.

This Transition-Canadian Zone habitat differs from the Upper Sonoran Zone habitat in which the three other known specimens were taken. Of the type specimen procured three miles east of Beaver, Utah, Osgood (Proc. Biol. Soc. Wash., vol. 22, p. 52, 1909) says that it " . . . . was caught about two hundred yards from running water on a dry rocky Upper Sonoran slope, where the vegetation was scant and practically restricted to *Juniperus*, *Artemisia*, and *Atriplex*." Indian Spring, 7700 feet, Mount Magruder, Esmeralda County, Nevada, where the second specimen was taken, would, as the writer remembers the place, answer to the description given by Osgood (*loc. cit.*) of the type locality if pinyon be added to the list of plants. The locality whence came the third specimen, Chiatovich Creek, 8200 feet, White Mountains, Esmeralda County, Nevada, is of similar zonal position and floral constitution. Here, on May 19, 1927, Miss Louise Kellogg trapped one of these shrews among sage brush on the floor of the narrow canyon whose sides were clothed with juniper, pinyon and sage brush, although the edge of the creek was fringed with aspens, willows and cotton-woods.

In connection with the present record of occurrence it may be well to recall that three shrews of the little known *Sorex merriami* group previously were taken in Arizona; though they were not of the species *Sorex leucogenys*. Two of these three specimens were from the Graham Mountains. They were recognized and named (Journ. Mamm., vol. 13, p. 259, 1932) as a new species. The other one of these three specimens was from Rose Peak. It was tentatively referred (*op. cit.*) to the species *Sorex merriami* with the suggestion that it might be an intergrade between *Sorex melanogenys* on the one hand and *Sorex leucogenys* or *Sorex merriami* on the other.

The fourth specimen of the *Sorex merriami* group from Arizona, the *Sorex leucogenys* from Sawmill Springs, comes from more than 150 miles northwest of Rose Peak. As previously intimated, it extends the range of the species *S. leu-*

cogenys across the Colorado River into Arizona and two hundred and thirty-five miles south and a little east of the type locality, near Beaver, Utah, which was geographically the nearest station of occurrence previously reported (see Jackson, N. Amer. Fauna, no. 51, p. 82, 1928).

As compared with *Sorex leucogenys*, adult female, no. 38398, Mus. Vert. Zool., from Chiatovich Creek, Esmeralda County, Nevada, no. 55181 from Sawmill Springs is darker above and below by a barely perceptible degree. The feet of the specimen from Arizona are lighter colored. No color difference can be detected on the tails of the two specimens. In the Arizona specimen only that part of the skull anterior to the interorbital region is preserved. This part of the skull has a lesser interorbital breadth; 3.4 millimeters as against 3.7 millimeters in the Nevada example. Also, in the Arizona specimen the unicuspid tooth rows are straight whereas in the Nevada animal each row is bent and their anterior halves are approximated so as to be parallel. However, since the tips of the unicuspids are inclined medially, this seeming difference might be due to the greater tooth wear in the specimen from Arizona.

Measurements of the specimen from Sawmill Springs are as follows: Total length, 98 mm.; length of tail, 33; length of hind foot, 12; palatal length, 7.1; least interorbital breadth, 3.4; maxillary breadth, 5.3; maxillary tooth row, 6.0. —E. Raymond Hall, *Museum of Vertebrate Zoology, Berkeley, California.*

THE EXTERNAL CHARACTERS OF BRACHYPHYLLA PUMILA MILLER

In a small collection of bats made by the Armstrong Santo Domingo Expedition for the American Museum of Natural History in 1932 are five alcoholic specimens of *Brachyphylla pumila* Miller, from a cave at Los Patos on the coast of the Province of Barahona, Santo Domingo. Mr. Gerrit S. Miller, Jr. has kindly compared the skulls of two of them with the cave material in the National Museum collection and states that they agree sufficiently well with Haitian specimens to be classified as *B. pumila*. As this bat was originally described from an imperfect skull (Miller, Proc. Biol. Soc. Washington, vol. 31, p. 39, May 16, 1918) and has since been recorded only from cave deposits (Miller, Smithsonian Misc. Coll., vol. 81, no. 9, p. 9, March 1929), the external characters have hitherto been unknown. In general appearance *Brachyphylla pumila* closely resembles *B. nana*, the Cuban species, and the only external differences appear to be the slightly smaller size and relatively smaller ears of the Santo Domingo bat. The light basal area of the fur in *B. pumila* is white. It is yellowish white in specimens of *B. cavernarum* that I have examined, and, according to Miller, grayish white in *B. nana*.

In cranial characters *B. pumila* needs no comparison with the large form inhabiting Porto Rico and the Virgin Islands. From the Cuban *B. nana*, as pointed out by Miller, it differs in broader rostrum and palate and larger molars. In the Los Patos specimens the interpterygoid fossa extends forward to within 1 mm. of the posterior outline of the palate as in *B. nana*, but it ends in a sharp pointed V instead of the more or less rounded angle of the Cuban species.

Average measurements of five adult males of *B. pumila*, and of an adult female *B. nana* (in second parentheses): Head and body, 77.3 mm. (75–78.5) (83); tibia, 24.2 mm. (22–25) (25); foot, 16 mm. (16–16) (15); forearm, 57 mm. (55–58) (60); first digit, 11.5 mm. (11–12) (12.4); second digit, 46.4 mm. (43–48) (48.2); third digit, 99 mm. (98–100) (102.3); fourth digit, 77 mm. (77–77) (80.4); fifth digit, 75 mm.

(75–75) (80.5); ear from meatus, 17.5 mm. (17–18) (22.6); ear from crown, 15 mm. (14–16) (17); width of ear, 13 mm. (13–13) (14). Cranial measurements essentially as in the type description.—G. G. Goodwin, *American Museum of Natural History, New York.*

THE INSECT FOOD OF THE BIG BROWN BAT

It is common knowledge that bats eat insects, but there appears to have been little effort directed toward determining what these insects are.

It was my opportunity to collect some pellets of *Eptesicus fuscus fuscus* in the attic of the home of Mr. Wilbur Frye, at Hanging Rock, West Virginia, late in August, 1931. A small colony of these bats occupied a space in the partition, and their droppings had accumulated for some time on the floor. A half-pint jar was filled with what was thought to be relatively fresh droppings; that is, those that were free from any dust and were reasonably bright and clean. It is not likely that those collected were dropped before early June. It is thus assumed that the contents of the pellets give a fair index to the summer food of this species in northern West Virginia.

Twenty-two hundred pellets were examined. These range in length from 6 to 16 mm., the average being 8 mm. The pellets were placed in water, a few at a time, allowed to soak thoroughly, then crushed or teased apart with dissecting needles and forceps. Identifiable remains, consisting principally of membranous wings, legs, mouthparts, etc. of insects were mounted on slides and examined more carefully, with a view to determining the family to which they belonged. Frequently ten pellets were passed in sequence before a fragment large enough to warrant even remote identification was found.

Because of the finely comminuted parts, determining the remains by the percentage-by-bulk method was impracticable, consequently percentages by frequency of occurrence are used. In all, about 300 wings were salvaged, and the best specimens of each kind were mounted for identification. Following is a list of the various orders of insects encountered, arranged in the order of their apparent abundance.

Coleoptera, 36.1; Hymenoptera, 26.3; Diptera, 13.2; Plecoptera, 6.5; Ephemeridae, 4.6; Hemiptera, 3.4; Trichoptera, 3.2; Neuroptera, 3.2; Mecoptera, 2.7; Orthoptera, .6.

Among the Coleoptera, beetles of the family Scarabaeidae occur most frequently. In general, we may say that this group, harboring the leaf chafers and May beetles, are on the whole injurious. Next in order occur members of the family Elateridae, which includes such destructive forms as the wire worms. Lampyrids are frequently eaten, but these insects are probably of benefit to man. In equal numbers were found beetles belonging to the Histeridae, which feed principally on carrion. Carabids were encountered in relatively few instances. These are generally recognized as being of value to man. The remains of several water beetles, Hydrophilidae, were recognized.

Hymenoptera were represented by flying ants in several instances. Likewise braconids, useful insects with parasitic habits, had been consumed in many instances. Ichneumonids were eaten by the bats, and one was recognized as belonging to the genus *Ophion*.

Diptera were represented chiefly by muscids, a group which embraces the house fly and its allies. A single wing of a cranefly, *Tipula*, was recognized.

Plecoptera remains were found frequently, and in every instance these stoneflies proved to be members of the genus *Isoperla*. Mayflies, hemipterous insects, caddis flies, lace-wing flies, scorpion flies (*Panorpa*), and a few orthopterous insects make up the remainder.

It is rather surprising that no lepidopterous remains were encountered. The wings of moths are usually bitten off by bats and discarded, yet if the bodies were eaten, we should expect to find some trace of scales. Scales were evident both in the stomach and droppings of the big eared bat, *Corynorhinus rafinesquii*, examined by the writer.

It is a pleasure to acknowledge the aid of Dr. W. T. M. Forbes in determining the insect remains.—W. J. Hamilton, Jr., *Cornell University, Ithaca, N. Y.*

ACCIDENTS TO BATS

In the Journal of Mammalogy for November, 1925 (vol. 6, no. 4), Marcus Ward Lyon, Jr. called attention to a note by Leslie T. Little (Auk, vol. 42, p. 284, 1925) on birds and a bat being caught by burdock burs. He reported also a similar observation of his own, made in 1892, of at least a dozen bats, probably *Myotis lucifugus*, caught by the burs of a large clump of burdocks.

Mr. Gerrit S. Miller, Jr. very kindly permits me to place on record a similar accident to a red bat, *Lasiurus borealis*. He found this animal, recently dead, caught on a clump of burdocks growing close to the side of a barn two miles south of Alexandria, Va., in August, 1918. The body was lying on the top of the bush, about two and a half feet above the ground. It seemed to Mr. Miller that the bat had probably swooped down after an insect, taking no care to avoid the burdock—this species being a frequenter of trees and used to brushing against foliage. Still attached to the branch, this specimen is preserved in alcohol as No. 219908 of the U. S. National Museum collection.

Examination: The bat rests on a small mass of burs on its ventral surface. Both of its wings are held somewhat firmly by the fine hooks on the burs which, however, seem unable to catch and hold the fine soft hair of the head and body. The alcohol may have had some effect on this, especially in view of the fact that the wings can be pushed away from the burs with little force—though more than the bat probably could have exerted.

There is one very remarkable feature. The bat's right wing, which appears to be partly spread, is really twisted or folded under, at the wrist joint, and it is the *dorsal* surface of its distal portion which adheres to the burs. And the forward or index finger edge of this part of the wing is directed to the rear—that is, the animal, as it lies, is headed in the opposite direction to that in which it was probably flying when arrested. The terminal part of the wing being held fast, the animal's momentum, aided by its immediate convulsive effort to pull loose, swung it completely about and down over the wing which was sharply flexed and supinated at the wrist joint as the fixed pivot of the turn. As the body fell, the left wing beating downward was also quickly caught and the animal held fast. This explanation of the picture assumes that the bat was "banking" in turning to the right,—was inclined nearly perpendicularly with the right wing pointing downward, at the instant that it brushed against the burs.

I have to report another type of accident to a red bat (*Lasiurus borealis*). In July or August, 1932, I found its partly mummified body hanging from the top wire of a barbed wire fence, along a well-travelled road in Maryland, a few miles north of Washington, D. C. Its interfemoral membrane had been pireced by one of the sharp wire points or barbs about half an inch from the end of its tail, on the left side, close to the vertebrae. A slit, three-eighths of an inch long, had been torn but the remaining bit of the membrane had held firm and the poor creature's speed and later struggles had drawn it tightly into the clefts between the transfixing barb and the wires coiled on either side, so that I had to use considerable force to free it.

The body hung straight down. The left wing is closed, the right partly so, the wrists held out a little way from the head, the hind limbs are partly fixed, the feet lying in front of the tail. Dried feces cling to the fur near the anus. The right wing is badly torn between digits 4 and 5, slightly between 3 and 4, and the loose, shrivelled membrane indicates it was torn while fresh, and probably by beating against the next set of barbs. The left wing shows only a small hole between digits 3 and 4.

Where the bat was hanging there were no trees, bushes or high plants anywhere near, on that side of the road, and the field behind the fence was closely cut and open. The bat probably was not attempting to hang up in such a place, nor does it seem probable that human hands had hung it there. This seems a more likely interpretation: The bat was flying low over the field and turned toward the road. It rose to clear the fence and depressed its tail (its "horizontal rudder") to descend immediately into the roadway. The barb which caught it slanted downward toward the field, so that the tail and interfemoral membrane must have been depressed while the animal was still rising and moving forward. It is surprising that the bat should not have allowed itself more clearance, especially if this was its regular hunting field and it was familiar with the fence, although it might have grazed the wire between two sets of barbs with impunity. It was apparently one of those careless acts that some animals seem more prone than others to commit.—Paul B. Johnson, *Washington, D. C.*

THE RED BAT IN THE WASHINGTON REGION IN WINTER

On February 19, 1933, a pleasantly warm day that brought out the first frogs of spring and started the alder tassels, I saw a red bat (*Lasiurus borealis borealis*) flying near Dumfries, Va., a little more than thirty miles in an air line southwest of Washington, D. C. The time was four in the afternoon, and the bat was circling back and forth in the warm sunshine over a deep cut in the highway where a stand of trees on the banks above gave protection from wind. From its actions it may have been feeding on gnats that were out in small numbers. The light was exceptionally favorable, the bat was near at hand, and there can be no mistake in the identification.

In this connection it is of interest to call attention again to another observation on this species, made in company with E. A. Preble and W. L. McAtee on November 17, 1917, when several red bats were seen and one was taken before sunset near Lorton, Va., at a point about twenty miles southwest of Washington.[1]

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[1] Published by V. Bailey, Proc. Biol. Soc. Washington, vol. 36, p. 133, 1932.

While the November record may concern individuals in southward migration the February occurrence supports Mr. Bailey's supposition in the reference just cited that the red bat may winter in this area. The time seems extraordinarily early for northward movement in this species.—ALEXANDER WETMORE, *U. S. National Museum, Washington, D. C.*

THE CLASSIFICATION OF THE GIBBONS

There are four well defined groups or types of gibbons, namely: (1) the *lar*-type, including most of the described forms and ranging from Assam and Upper Burma southward through the Malay Peninsula to Sumatra and Java, and eastward through Siam, Cambodia, Cochinchina and Borneo; (2) the *concolor*-type, with three or four closely interrelated forms known from Laos, Annam, Tonkin and Hainan; (3) the siamang or great gibbon of Sumatra and the southern part of the Malay Peninsula; and (4) the dwarf gibbon of the Mentawi Islands off the southwest coast of Sumatra.

In the systematic treatment of these four groups there has been little uniformity. The usage prevalent during the past twenty years has been to refer most of the species to the genus *Hylobates* and to place the great gibbon and the dwarf gibbon together in the genus *Symphalangus*. This is evidently the arrangement accepted by Pocock[1] as recently as 1927, though he then limited his discussion to the members of the restricted genus *Hylobates*. Two years later Kloss[2] regarded the dwarf gibbon as so perfectly intermediate between the ordinary gibbons and the siamang that he did away with *Symphalangus* as a separate group and placed all the gibbons in the one genus *Hylobates*. Neither of these views met with the approval of Dr. Adolph Schultz, the last author to discuss the subject of gibbon classification. After an exhaustive study of "The skeleton of the trunk and limbs of higher primates" he concluded[3] that *Symphalangus*, as represented by the great gibbon or true siamang, is a genus distinct from *Hylobates*, and that the dwarf gibbon is so unlike the true siamang that it "should really either be moved into the genus *Hylobates*, or else should constitute a new genus of its own." Two years later, having examined much additional material, he decided to place the dwarf gibbon in the genus *Hylobates*, but to establish for its reception a special subgenus *Brachitanytes*.[4] That the members of the *concolor*-group differ conspicuously from the gibbons of the *lar*-type is a fact that has been remarked on by both Pocock (who noticed the peculiar frontal profile of the skull and thought he had found "key" characters in the female external genitalia) and Kloss (who called attention to the unusual manner of growth of the hair on the crown).

It seems obvious that each of these four types of gibbons is of more than specific importance. One of them certainly includes several distinct species. Moreover, the variations within a group are never sufficiently great to give rise to confusion with regard to group limits when all of the characters of individuals are taken into consideration. Any well prepared adult or half-grown specimen can be referred to its group at sight. And, furthermore, gibbons are now so well known that the future discovery of perplexing species is very improbable. But

[1] Proc. Zool. Soc. London, 1927, pp. 719–741.
[2] Proc. Zool. Soc. London, 1929, pp. 113–127.
[3] Human Biology, vol. 2, p. 400. September, 1930.
[4] Journ. Mamm., vol. 13, pp. 368–369. November 10, 1932.

the types are distinguished from each other chiefly by mere varying degrees of development of peculiarities that are, for the most part, common to all the gibbons. The unusual direction of growth of the crown hair in the *concolor*-group seems to be the only example of an external feature that is so strictly confined to a single group that it is not approached by some member of another. The same is almost true of the sexual differentiation pattern of hair length on the crown in all the known members of the *concolor*-group; but this character is not constant, as it shows one conspicuous individual exception among the twenty-three specimens examined. The cranial distinctions pointed out by Pocock and the group peculiarities in the skeleton of the trunk and limbs recorded by Schultz are mostly (though perhaps not entirely) average characters that can not be relied on as diagnostic of every individual specimen. Under these circumstances, and in view of the small number of species concerned, I think that the most convenient course is to unite all four groups in the genus *Hylobates*, and to distinguish them from each other subgenerically as follows:

Key to the Subgenera of Hylobates

Hair of vertex directed upward; sexes usually with a differential hair-length pattern on the head (hairs elongated at middle of crown in males, at sides of crown in females; only 1 exception among 23 specimens); gular sac present (small) in male only; sagittal profile of skull nearly straight from front of nasal bones to level of upper margins of orbits; testicles descending into a normal pendulous scrotum that is well developed in the young at birth.

Nomascus subgen. nov. (type *Hylobates leucogenys* Ogilby)

Hair of vertex directed backward; sexes with no differential hair-length pattern on the head; gular sac present (large) in both sexes or not present in either; sagittal profile of skull strongly curved (often double curved) in region extending from front of nasal bones to level of upper margins of orbits; testicles not descending into a normal pendulous scrotum but each remaining beneath a separate fold or utriculation of slightly modified body skin, one on each side of the base of the penis.

Gular sac present in both sexes; hair on both sides of forearm directed upward toward elbow; testicles descending partly below base of penis; (hair of approximately equal length at middle and sides of crown); arm excessively elongated, the intermembral index ranging from 145 to 152 (Schultz).

Symphalangus Gloger (Type *Pithecus syndactylus* Desmarest)

Gular sac absent in both sexes; hair on radial side of forearm directed downward toward thumb; testicles remaining mostly or entirely above base of penis; arms less elongated, the intermembral index ranging from 124 to 136.9 (Schultz).

Hair at sides of crown elongated; throat thickly furred; webbing between second and third toes less frequent (Schultz).

Hylobates Illiger (Type *Homo lar* Linnaeus)

Hair at sides of crown not elongated; throat thinly furred; webbing between second and third toes more frequent (Schultz).

Brachitanytes Schultz (Type *Symphalangus klossii* Miller)

—Gerrit S. Miller, Jr., U. S. *National Museum.*

PLEISTOCENE PRAIRIE-DOG FROM FREDERICK, OKLAHOMA

A prairie-dog lower jaw was found in the Pleistocene deposits at Holloman's Gravel Pits, one mile north of Frederick, Oklahoma, by Dr. H. E. Wood, 2nd., on June 11, 1932. These gravel pits are one of the few recorded localities in North America where unmistakable human artifacts occur in definite association with Pleistocene mammals in a deposit of demonstrable antiquity.[1] As the fauna previously recorded from Frederick is entirely a macrofauna,[2] this find offers another instance where the lack of microfauna in the collections is due, not to absence from the formation, but to its not having been found. The lower jaw, a right ramus containing P_4–M_3 (no. AW101), is referable to *Cynomys ludovicianus arizonensis* (Mearns), differing from *C. l. ludovicianus*, which occurs around Frederick at the present time, in the relative lengthening of M_3 and the relative shortening of the other teeth, as well as in having a narrower valley between the protoconid and entoconid in all the teeth—characters that unite it with *C. ludovicianus arizonensis*. This race is at present confined to southeastern Arizona, New Mexico, and Trans-Pecos Texas, so that a change in the relative distribution of the two forms has taken place since the Pleistocene, unless there has been an evolutionary modification. Fossil specimens of *C. ludovicianus*, subspecies not specified, have already been reported from the Pleistocene of Folsom, New Mexico and of Hay Springs, Nebraska.—Albert Elmer Wood, *Long Island University, Brooklyn, N. Y.*

AQUATIC HABITS OF PEROMYSCUS MANICULATUS

On July 2, 1932, on the southwest slope of Cuddy Mountain, Washington County, Idaho, I walked down to the edge of a small stream at 8:45 p.m., looking for possible amphibians and water shrews. On the opposite side of the creek the beam from my flashlight cut across a white-footed mouse (*Peromyscus maniculatus artemisiae*) that was moving about in water approximately one-half inch deep among some small rocks (three to six inches in diameter). The animal seemed to be seeking something beneath these stones and continued moving upstream slowly, apparently oblivious to the light. The creek at this point was overhung with alders that lined its banks. There was a small wooden bridge crossing the stream about fifteen feet above where I first noted the mouse. When it was directly beneath the center of this it jumped into the swift flowing water and swam across to the side on which I was standing and, without even pausing to shake itself, darted beneath the bank and was lost to sight. The stream was ten feet across at this point and was flowing quite swiftly over numerous stones in its course, thus being relatively rough. Despite this, however, the animal swam with amaz-

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[1] Sellards, E. H. 1932. Geologic relations of deposits reported to contain artifacts at Frederick, Oklahoma. Bull. Geol. Soc. Amer., vol. 43, pp. 783–796, pl. 13.

[2] Hay, O. P. and H. J. Cook. 1930. Fossil vertebrates collected near, or in association with, human artifacts at localities near Colorado, Texas; Frederick, Oklahoma; and Folsom, New Mexico. Proc. Colorado Mus. Nat. Hist., vol. 9, no. 2, pp. 4–40, pls. 1–12.

ing rapidity, and landed only ten feet down stream on the opposite shore.—ROBERT T. ORR, *Museum of Vertebrate Zoology, University of California, Berkeley, California.*

THE SUPPOSED GENERA AEPEOMYS AND INOMYS

Some years ago (1920), in company with Mr. H. B. Conover, I made a collection of mammals in the Merida region of Venezuela with the object of obtaining well prepared topotypes of the various forms described from material collected by Briceño Gabaldon and Sons. Owing to the number of names already proposed, nothing new was expected from the region and it was with some surprise that a small series of an apparently new and well-distinguished species of *Thomasomys* was collected. Before proposing another name, however, I took the precaution of sending a specimen to Oldfield Thomas for his opinion. It was returned promptly without comment but with the name *Aepeomys lugens* written on its label. For some time there was no opportunity to give it further examination and it was assumed that its reference to *Thomasomys* had been mistaken. Meanwhile, all other specimens of *Thomasomys* in the Field Museum were sent as a loan to H. E. Anthony for use in his proposed study of *Thomasomys*. The return of this material and the appearance of Anthony's *Thomasomys ottleyi* (Amer. Mus. Novit. No. 548, pp. 1–2, July 8, 1932) have brought the matter to attention again. Apparently the species judged to be a new form of *Thomasomys* is in reality *lugens*—the type of the supposed genus *Aepeomys*. Since neither Anthony nor I find any characters of generic importance, it may be concluded that *Aepeomys* is a synonym of *Thomasomys* and *ottleyi* is only a later name for *lugens*. The other forms, *vulcani* and *fuscatus*, referred to *Aepeomys*, have not been critically examined.

The supposed genus *Inomys* (Thomas, Ann & Mag. Nat. Hist., (8), vol. 20, p. 197, 1917) also appears to be inseparable from *Thomasomys*. In 1930, I examined the type species of *Inomys* (*Oryzomys incanus* Thomas, Ann. & Mag. Nat. Hist., (6), vol. 14, p. 350, 1894) in the British Museum and was unable to find any characters by which it might be distinguished generically from various other species referred to *Thomasomys*. Like the type of *Aepeomys*, it is one of those species in which the elongation of the rostrum and the narrowness of the infraorbital plate are somewhat extreme, but the variation of these features within the group is such that sharp lines of separation cannot be drawn. Comparison of the type of *incanus* with specimens of *Thomasomys fraternus*, in the British Museum, shows them to be so similar that even a subspecific distinction may be questionable.

Since making these comparisons, I find in Field Museum a small series from the Huanuco Mountains of Central Peru which apparently should be referred to *fraternus* or *incanus*, as judged by the descriptions. The unique type of *incanus*, therefore, is now supplemented by considerable additional material which gives no support to the supposition that it represents a genus distinct from *Thomasomys*. The type species of *Thomasomys* (*cinereus*), it is true, is one of those with a relatively short rostrum and fairly well-developed infraorbital plate but, as stated before, these characters are so variable and such gradations exist from one species to another that, certainly for the present, the attempt to use them for generic distinctions leads only to confusion.

The supposed difference in hypsodontism mentioned by Thomas in his review in 1917 (l.c.) is not appreciable in the material at hand. It is significant that in this review, although an attempt was made to characterize *Inomys*, there was no reference to *Aepeomys*.—WILFRED H. OSGOOD, *Field Museum, Chicago, Illinois.*

THE RED TREE-MOUSE PREYED UPON BY THE SPOTTED OWL

Papers dealing with the natural history of the red tree-mouse, *Phenacomys longicaudus*, have contributed little or nothing to the subject of enemies of this peculiarly arboreal microtine, with the exception of A. B. Howell's discourse (N. Am. Fauna, No. 48, 1926, pp. 59–60) on probable enemies and adverse factors in the environment. The small size of litters (two or three in each), even though breeding may occur throughout the year, is conducive to speculation on the question whether as serious a toll is levied upon this species by predators as upon its ground dwelling relatives. Howell (p. 60) states that "raptorial birds must be the chief active enemy with which these mice have to contend. . . . ; owls, especially screech owls, would be attracted by the mice, foraging among the foliage of a tree." He records considerable damage to litters of young by Steller jays (*Cyanocitta stelleri*).

On May 26, 1932, I collected a female spotted owl (*Strix occidentalis caurina*) at a point on Eel River, ten miles north of Garberville, Mendocino County, California. The bird was taken at about 9 a. m. in a madrone and Douglas fir wood and had in its stomach a nearly perfect skull of *Phenacomys longicaudus*, together with much red hair that was at once recognizable as of this species. Mr. S. B. Benson has checked the identification of the skull for me.

Since the northwest race of spotted owl is quite characteristic of, and not uncommon in, the Douglas fir and redwood belt of northern coastal California, I surmise that it is as potent an enemy of the tree mouse as is any other species of owl. No actual instances of capture by other owls appear to be known. Screech owls do not seem to be particularly abundant in the region. Spotted owls have been taken a number of times at Mr. H. E. Wilder's place near Carlotta, Humboldt County, California, where much of the natural history information pertaining to *Phenacomys longicaudus* has been obtained. In my experience spotted owls move about at night within the trees and foliage, not on the tree tops or in the openings in the forest as do horned owls, and hence they would naturally operate within the forage range of this mouse.—ALDEN H. MILLER, *Museum of Vertebrate Zoology, Berkeley, California.*

A CORRECTION CONCERNING THE SPECIES OF COTTONTAIL THAT BRED IN CAPTIVITY

The cottontail rabbit that bred in captivity in my laboratory, as reported in the Journal of Mammalogy (vol. 10, pp. 225–229), was wrongly identified as *Sylvilagus audubonii neomexicanus*. The animals actually were *Sylvilagus floridanus alacer*, and all references to *neomexicanus* in the paper cited should be changed to *alacer*. At the time the paper was prepared most of the rabbits were still alive. Living *alacer* differs so strikingly from *mearnsii* or *similis* in size and behavior that I was misled into believing that my subjects must belong to the species *audubonii*. As shown by these animals *S. f. alacer* is smaller and much more active than either *S. f. mearnsii* or *S. f. similis*. In activity *alacer* resembles *S. a. baileyi* rather closely.—LEE R. DICE, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

THE STATUS OF THE EXTINCT AMERICAN "ELAND"

In continuing the investigation of the fossil mammalian fauna from Cumberland Cave in western Maryland, left incomplete by the late Dr. J. W. Gidley, it

seemed advisable to review rather critically the evidence supporting recognition of an African antilopine form in the Pleistocene of North America. In 1913 Gidley[1] described an upper dentition as belonging to a new species of eland, *Taurotragus americanus*, and in so doing indicated a somewhat closer faunal relationship with Africa than seems probable.

As supplementary evidence in support of Ethiopian faunal affinities with this continent, Gidley cited the occurrence of *Ilingoceros*[2] and *Sphenophalos* in the Pliocene of Nevada. These genera were formerly regarded as showing strepsicerine affinities but later work[3] has demonstrated one, if not both, of them to be more nearly related to the antilocaprids, and it is entirely possible that they are of indigenous origin.

Unfortunately, nothing is known regarding the horns which *"Taurotragus" americanus* presumably had. However, a lower dentition in the Cumberland Cave collection, which belongs beyond reasonable doubt to the same kind of animal as that represented by the type upper dentition, aids appreciably in a better understanding of the relationship of this bovid-like form.

The upper and lower dentition of *"Taurotragus" americanus* is characterized, in comparison with other North American bovids, by being distinctly hypsodont and having relatively large premolars. Also, the crescentic enamel fossettes in the molar teeth are noticeably compressed transversely. The upper cheek teeth widen abruptly toward the roots, and become somewhat shorter antero-posteriorly with wear. The anterior and median external styles on the upper molars are heavy, although the posterior style is noticeably reduced in both molars and premolars. The lower molars have well developed external lobes, particularly M_1 and M_2, and have a reduced antero-internal style. Perhaps the most important dental feature is the progressive development of the permanent lower premolars. P_2 shows a folding of the enamel similar to that exhibited by P_3 in specimens of *Ovibos*. In the fossil, P_3 has its inner wall extended across the deeply impressed enamel folds so that they are closed lingually for the greater portion of the crown height. P_4 is characterized by a well developed posterior lobe which is set off from the anterior lobe by a distinct groove placed well forward on both the inner and outer surfaces of the tooth.

The resemblance of the upper dentition to that of an eland is noticeable, although Dr. Paul Matchie[4] was unable to find in a series of 80 skulls a set of teeth in the African eland which corresponded to Gidley's figure of the fossil dentition. Dr. O. P. Hay,[5] while recognizing Gidley's determination, called attention to several characters in which the dentition of the existing eland differed from that of the fossil. These differences included thinner and more outstanding anterior and posterior external styles on P^2 and P^4 as well as a less flattened internal face on these teeth in the African eland. In the lower molars of the eland it is noted that M_1

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[1] J. W. Gidley, Smithsonian Misc. Coll., vol. 60, no. 27, pp. 1–3, 1913.

[2] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 319–330, 1909.

[3] E. L. Furlong, Carnegie Inst. of Wash., Publ. 418, pp. 27–36, 1932; also R. A. Stirton, Amer. Jour. Sci., ser. 5, vol. 24, pp. 46–51, 1932.

[4] Paul Matchie, Sitz.-Ber. Ges. Naturf. Freunde, Berlin, p. 258, 1913.

[5] O. P. Hay, Proc. U. S. Nat. Mus., vol. 58, pp. 113–115, 1920.

is relatively narrow and M_3 relatively wide as compared with those in the fossil jaw, and the lower premolars, though equally large, are distinctly less progressive.

The dental characters of *"Taurotragus" americanus* readily distinguish it from the American bison, and to a less extent from *Ovibos*. Of the extinct bovid forms described from this continent *Preptoceras*[6] and *Euceratherium*[7] appear to have teeth that most closely resemble those of *"Taurotragus" americanus*. This group, which is so well represented in the northern California caves, is characterized by hypsodont teeth exhibiting some points of resemblance to those of the modern African eland. Obvious differences, however, are seen in the shape and attitude of the horns and also in the characters of the basicranial region. The teeth in both *Preptoceras sinclairi* and *Euceratherium collinum* are of smaller size and the upper molars show somewhat weaker external styles than in *"Taurotragus" americanus*, but the structural conformation of the several teeth in the tooth row is essentially the same as that of the Cumberland Cave form. The characters of the lower dentition of this group were not made known until 1927, at which time Dr. Chester Stock and E. L. Furlong[8] described remains from the tar pits at McKittrick, California. The lower dentition figured in their paper is strikingly like that of *"Taurotragus" americanus* in both hypsodonty and enamel pattern, but is of smaller size and the postero-external groove on the third and fourth premolars is somewhat more deeply impressed.

A reexamination of the types of *Euceratherium collinum* and *Preptoceras sinclairi*, kindly loaned to me by the University of California, strongly suggests that the differences separating these two forms may not exceed the limits of individual variation and that the type of *Euceratherium collinum*, which is from an adult individual, may represent a female, and the type of *Preptoceras sinclairi*, though more immature, may be a male. Furthermore, the McKittrick specimen referred to *Preptoceras* shows, as indicated by Stock and Furlong, several points of resemblance to *Euceratherium*, making generic allocation not entirely satisfactory.

In view of the observed dental similarities between the Cumberland Cave form and specimens of the *Preptoceras-Euceratherium* group it seems probable that our form is related to this group rather than to *Taurotragus*. It is possible that an undescribed genus is represented but in the absence of material exhibiting clearly the diagnostic criteria it seems preferable to refer this form tentatively to *Euceratherium*. Additional material from loess in the vicinity of Alton, Illinois, identified by Hay[9] as *Taurotragus*, may also be referable to *Euceratherium* (?) *americanum*.—C. LEWIS GAZIN, *U. S. National Museum, Washington, D. C.*

A THREE-HORNED WAPITI (CERVUS CANADENSIS CANADENSIS)

The Wichita Mountains lie in Comanche County in southwestern Oklahoma. When the Kiowa and Comanche Indian Reservation was thrown open to settlement, this being the last reservation opened in the state, a tract of land embrac-

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[6] E. L. Furlong, Univ. Calif. Publ., Bull. Dept. Geol., vol. 4, pp. 163–169, 1905.

[7] W. J. Sinclair and E. L. Furlong, Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, pp. 411–418, 1904.

[8] Chester Stock and E. L. Furlong, Univ. Calif. Publ., Bull. Dept. Geol., vol. 16, pp. 409–434, 1927.

[9] O. P. Hay, *ibid.*, pp. 113–115, 1920.

ing the major portion of these mountains was set aside as a natural forest reserve by President McKinley, July 4, 1901. It was designated as the Wichita National Forest and Game Preserve by President Roosevelt, June 2, 1905. It comprised an area of 61,480 acres of plain, mountains, and oak forest. In 1906 a herd of 15 buffalo was liberated in an area of 8000 acres enclosed by a heavy fence. These have increased to about 300 head.

FIG. 1. ABNORMAL ANTLERS OF A WAPITI

One bull wapiti was brought from Wichita, Kansas, in 1908. From Idaho, a herd of 5 cows was obtained in 1911, and 3 bulls and 12 cows in 1912. They were all liberated in the buffalo pasture and have increased so that they now number about 375. In order to keep the herds within limits of what the pasture will support some surplus animals are sold annually to hunters and others. On October 22, 1932, it was my good fortune while hunting in the pasture to secure a large bull wapiti with exceptional horns.

Apparently the horns had received an injury during a very early stage of growth. The right horn was normal and bore five points, but on the left side there were two distinct antlers. One left horn in the normal location was well developed with five points, but lacked the normal brow tine and had no burr at the base.

About two inches in front of this horn and over the left eye was a well developed third horn with four tines (see figure) and a burr. The extra horn appeared to take the place of the brown tine on the left side and to have been split off from it at a very early age. The skin about both left horns was sore and full of pus at the base of the horn, although the bone appeared uninjured. The hair was partly worn from this area by constant rubbing.

The animal was carefully examined for parasites both external and internal by Mr. J. M. Ward and myself. There were no internal parasites. We were able to find four ticks, which were submitted for identification to Professor C. E. Sanborn of Oklahoma A. and M. College. Three of them, two females and a male, were *Dermacentor albipictus* Pack. This tick, Professor Sanborn states, "was first taken on the wapiti and is hence known as the wapiti tick. It is a one-host tick and may also be termed a winter tick." The other tick, a male, was *Ixodes scapularis* Say. This "is a new record in the state, I believe. I have examined numerous ticks from the Wichita National Forest taken from sheep and elk, but was never able to obtain *I. scapularis*."

It is indeed interesting that this elk should have not only a remarkable set of horns but also harbor a new tick for this region.

The head, although not large compared to some of the northern records, is one of the best taken in the Wichitas. It measured: (a) length of outside curve, 40 inches in both right and left horns, of extra horn 25¼ inches; (b) circumference of main beam above brow tines, right horn 5 inches, left horn 6⅛, extra horn 5; (c) circumference of burr, right horn 9, front left 8¼; (d) spread, 39.

Apparently the northern wapiti, although coming from the Idaho stock, has degenerated somewhat in size. There was no way of weighing the animal. The head was mounted by the author and is in his possession.—RALPH D. BIRD, *University of Oklahoma, Norman, Oklahoma.*

RECENT LITERATURE

Gyldenstolpe, Nils. A MANUAL OF NEOTROPICAL SIGMODONT RODENTS. Kungl. Svenska Vetensk. Handl., ser. 3, vol. 11, no. 3, pp. 1–164, pls. 1–18, 1932.

Stock-taking in the taxonomy of mammals, which was so usefully carried out by Trouessart during several decades, has had but little attention recently. For North America and for western Europe we have reliable lists, but for Asia, Africa, and South America there has been little or nothing published. Count Gyldenstolpe has now provided, not a complete list of neotropical mammals, but a list of the largest and most difficult group of them, the sigmodont rodents.

A brief introduction indicates the author's realization of the difficulties of his task and of the necessarily tentative nature of the results. Following the original citation and statement of type or type locality, descriptive text is given for each genus, species, and subspecies. This text is mainly compiled from original descriptions and is of use only in so far as it may have been reliable at its source. Keys, of course, are out of the question and are not attempted even for genera. Tables of measurements and a series of eighteen half-tone plates of skulls add greatly to the value of the work and serve further to justify the title of "Manual."

The need for such a comprehensive review is emphasized by comparison with previous lists showing the very rapid expansion of the subject which has been under way in recent years. In Trouessart's list of 1897, the number of recognized forms in the group was 159, in 1899 it was 186, in 1904 it became 299, and in 1932 it had grown to the large total of 516. Another interesting enumeration is that which shows the extraordinary extent to which one man has dominated the field. Of the present total of 516, no less than 273 are credited to the late Oldfield Thomas of the British Museum.

The author has had the practically indispensable privilege of access to the collections of the British Museum and doubtless also to pertinent papers and records. His treatment of genera and species, therefore, reflects quite accurately the views of Thomas. Anything else, at this time, would scarcely have been possible. The area covered by the list is South America south of Panama and it is thus supplementary to Miller's "List of North American Recent Mammals." The restriction against the expression of personal opinion, so consistently followed by Miller, has not been adopted, however, and the results are not always fortunate.

Genera are freely recognized, including some which even Thomas, with his rather liberal standards, proposed only as subgenera. On the other hand, species and subspecies are in some cases discredited, although it is obvious that specimens representing them have not been examined. The attempt to assign all forms to their proper genera leads to some absurdities, but in the present state of knowledge, it is difficult to see any better course, and it is plain that the author has given much study to actual material as well as to literature. It is a little disconcerting to find *Oryzomys longicaudatus* with its subspecies *destructor* placed in *Oryzomys*, while *stolzmanni* and others no more than subspecifically separable appear some pages farther on under *Oligoryzomys*. The difficulties were recognized as insuperable in forty-eight cases which are separately enumerated as "Incertae sedis." These are mainly the troublesome names applied by Philippi to Chilean rodents. Others of Philippi's names are definitely allocated, for the most

part on the basis of Wolffsohn's published opinions, but with some inexplicable exceptions. *Mus dolichonyx*, which certainly is not a *Phyllotis*, is placed under *P. darwini*, and *Mus simpsoni*, probably by following Trouessart, is recognized as a supposed valid species of *Holochilus*, although no *Holochilus* has otherwise been recorded from Chile nor even near Chile, and although the type, which I have examined in Santiago, is plainly a Norway rat. *Mus pusillus* is given place as a possibly recognizable *Akodon*, although the description and figure are far from conclusive as to its generic position. *Mus mochae* is assigned to *Irenomys* on the basis of a skull in the British Museum alleged but not demonstrated to be the type.

The sequence of genera, and of species under genera, is obviously provisional, and if not wholly arbitrary is at most not much better. The very specialized fish-eating genus *Ichthyomys* and its allies stand in primary position followed immediately by *Oryzomys* which is the most widely distributed and probably the most generalized. Between *Oryzomys* and the closely allied *Oecomys*, eight other genera intervene, including some at least which have much greater affinities elsewhere. The table of measurements follows European practice and gives "head and body," but not total length. To this there would be no objection if the total lengths published by American authors were given or if head and body measurements were derived from them, but this has not been done, with the result that for many species only the measurements of the tail and hind foot appear.

A critical attitude toward this paper seems justified only on the ground that it is directed toward the subject rather than the author. The difficulties are enormous and it is doubtful if any mammalogist could have produced a better result at this time. The author, in his introduction, amply indicates the shortcomings inherent in his task but has not allowed them to deter him from its completion in a form to accomplish his main purpose—"to get a general view of the multitude of genera and species that have been described." For this all mammalogists should be grateful to him.—WILFRED H. OSGOOD.

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mal-like reptiles, and clearly show every step that has led to the warm-blooded mammals. We will then know for sure whether the appearance on the earth of mammals has been the result of blind chance, or whether it has been due to the guidance of some intelligence."]

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pls. 2. October 24, 1931. (New: *Sivanasua* for *Ailuravus viverroides* Schlosser, *Martes woodwardi*, *Enhydriodon* (?) *latipes*, *Sivaonyx* for *Lutra bathygnathus* Lydekker, *Felis neas*.)

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CORRESPONDENCE

TO THE MEMBERS OF THE AMERICAN SOCIETY OF MAMMALOGISTS

Editor, Journal of Mammalogy:

The writer has described the occurrence of yellow lenses in the eyes of diurnal Sciuridae (*Copeia*, 1931, 125–7) and is attempting to determine the chemical nature of the pigment involved. The chemical behavior of this pigment, for which the name *lentiflavin* is proposed, is uncertain; it may be either a true melanin or a "melanoid." Decision depends upon whether the pigment is present in the lenses of complete albinos.

Albino squirrels are rare, and the writer has thought that the desired observation might be made sooner if mammalogists, to whom such squirrels might be brought, were apprised of the need for it.

The excised fresh lens should be compared directly with that of a normal conspecific squirrel, the lenses being immersed in normal saline and observed in daylight. If *some* coloration is found it should be carefully estimated in terms of the normal; full coloration or none at all are, however, more probable alternatives.

The undersigned will be glad to receive a live albino of any diurnal sciurid species, and will be equally happy if this observation is made by some other investigator.

GORDON L. WALLS,
National Research Fellow in Zoology,
University of Michigan, Ann Arbor, Michigan.

Editor, Journal of Mammalogy:

I am making a special effort to bring together for the files of the American Museum of Natural History all available information concerning the occurrence and last records of big game animals such as wolf, panther, moose, caribou, wapiti (elk) and bison, in any of the states east of the Mississippi, and especially in those of the Atlantic seaboard.

Although I have been able already to accumulate considerable information, I am desirous of going further and making our files on this subject as complete as is reasonably possible. Many published records are so scattered in sporting magazines, historical State records and scientific reports that it would be practically impossible to make a satisfactory report without the cooperation of mammalogists, sportsmen and State historians. Therefore I wish to ask those readers of the Journal of Mammalogy who have any information available on this subject or can suggest useful references to be so kind as to communicate with me.

G. G. GOODWIN,
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New York, N. Y.